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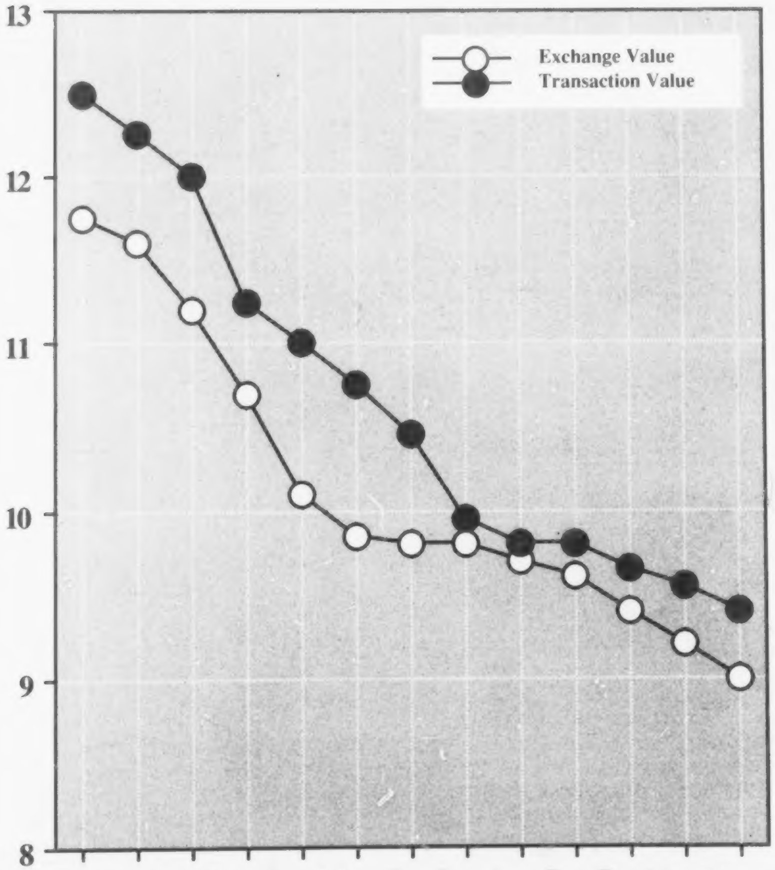
NUEXCO

1989 Annual Review



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NUEXCO

To Our Readers

NUEXCO is pleased to present our *1989 Annual Review,* the ninth in the series that covers nuclear fuel market price movements and other industry developments each year.

NUEXCO's first *Annual Review* appeared as part of the January and February 1982 Monthly Reports. It contained 25 pages of 1981 developments, and its preparation involved only a handful of people. As the market has expanded, however, so has our *Annual Review.* The 1984 edition, which contained more than 50 pages and involved more than a dozen people, marked the first release of the *Annual Review* as a separate publication. The *1989 Annual Review*, covering nearly 100 pages, makes use of contributions from more than 25 professionals from the NUEXCO group of companies.

From the first edition to this one, however, it is the diligent efforts and professional expertise of the people involved that have made our *Annual Review* possible. We trust that you will find this edition informative and useful.

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MARKET DEVELOPMENTS

NATURAL URANIUM

Overview

World uranium prices continued their downward course in 1989, reaching their lowest level ever in constant dollars. The NUEXCO Exchange Value (**Table 1**) fell 23 percent from December 31, 1988, while the UF_6 Value (**Table 1**) dropped 25 percent. The Exchange Value fell from 12 percent to 27 percent in selected currencies (**Table 3**). Aggressive inventory sellers and lenders dominated the market, and the volume of uranium sold for near-term delivery more than doubled (up 120 percent from 1988).

The year 1989 heralded numerous structural changes in the uranium market, resulting from political, social, and economic developments in various parts of the world. *Perestroika* in the Soviet Union and increasing democratization in other East European countries, such as Czechoslovakia and Hungary, led to their emergence as potential uranium suppliers. As political barriers fall, the nuclear industries of these East European countries are being integrated into the international market. Namibia's independence in early 1990 made Rössing's uranium politically acceptable once again throughout the market.

As a result of China's mid-year crackdown on domestic political protest, some customers temporarily refused to consider the purchase of Chinese uranium. However, the

Table 1
1989 NUEXCO NATURAL URANIUM
SPOT MARKET PRICE INDICATORS

Determined as of the last day of the Month	Published in Report Number	Exchange Value[1] (Per Pound U_3O_8)	UF_6 Value[1] (Per Kg U as UF_6)	Transaction Value[1]			
				Per Pound U_3O_8	Number of Transactions	Number of Months	Million Pounds Equivalent U_3O_8
January	246	$11.60	$34.75	$12.25	22	3	4.5
February	247	$11.20	$34.00	$12.00	21	3	4.3
March	248	$10.70	$33.00	$11.25	22	3	4.8
April	249	$10.10	$30.50	$11.00	29	3	6.4
May	250	$ 9.85	$30.25	$10.75	31	3	7.1
June	251	$ 9.80	$30.25	$10.45	27	3	5.5
July	252	$ 9.80	$30.00	$ 9.95	19	3	3.4
August	253	$ 9.70	$29.75	$ 9.80	15	3	2.1
September	254	$ 9.60	$29.75	$ 9.80	19	4	2.7
October	255	$ 9.40	$28.25	$ 9.65	17	4	2.5
November	256	$ 9.20	$27.75	$ 9.55	17	3	3.5
December	257	$ 9.00	$26.50	$ 9.40	21	3	4.2
Averages[2]		**$10.00**	**$30.40**	**$10.34**[3]	**22**	**3**	**4.3**

[1] See **Table 2** for definitions.

[2] Simple arithmetic averages, except where noted.

[3] Volume-weighted annual average.

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China Nuclear Energy Industry Corporation (CNEIC) met all of its contract commitments, and China has reaffirmed its long-term commitment to make nuclear fuel material available to the market.

In North America, unlike in recent years, pending political or legislative events had little effect on market activity. The US/Canada Free Trade Agreement (FTA), which gave Canadian and US uranium essentially equal status in each country, became effective January 1, 1989. The five-year-old lawsuit against the US Department of Energy (DOE) had raised hopes among US producers of a continuing US-origin uranium premium, but the FTA's ratification extinguished any near-term chance of government protection. The plaintiffs withdrew their suit in late January.

Supply and Demand

Supply

On average, active uranium supply declined in 1989, compared to 1988, when NUEXCO reported 5.6 to 8.1 million pounds equivalent U_3O_8 available for sale monthly.

Table 2
NUEXCO MARKET VALUES: DEFINITIONS, DERIVATIONS, AND COMMENTS

DEFINITIONS

[1] The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

[2] The **UF_6 Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

[3] The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

[4] The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated,

[5] The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

[6] The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
b. At least ten transactions;
c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US$.
- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.
- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values.**
- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.
- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.
- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.
- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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Average active supply for 1989 averaged 5.4 million pounds, and fell below 5 million pounds during seven months of the year (**Table 4**). As a result of historically low uranium prices, some producers, including such prominent suppliers as CNEIC and Cameco, early in the year withdrew from spot market selling. Their absence was noticeable, but material made available from a variety of sources maintained the substantial uranium oversupply. Those sources included:

- production and inventories from new suppliers;
- liquidation of excess inventories;
- material borrowed for current sale and later replacement;
- material liberated in de-conversion and de-enrichment transactions.

Many transactions involved more than one of these elements. For example, enriched uranium could be borrowed by a trader, de-enriched, combined with natural uranium from a utility's excess inventory, and then delivered to meet current commitments or offered for sale.

Buyers' and sellers' perceptions of a persistent supply excess played a key role in continuing the uranium price decline that had been underway at the end of 1988. For example, early in 1989 the market began anticipating the liquidation of several government and utility uranium stockpiles, helping to create in buyers' and sellers' minds the expectation of strong competition among suppliers for each order.

Developments in Australia also increased buyers' and sellers' perceptions of supply excesses. Early in the year, fearing Energy Resources of Australia's (ERA) European customers would cancel their high-priced, long-term contracts, the Australian government approved several contract renegotiations at US$26 per pound equivalent

Table 3
1989 NUEXCO EXCHANGE VALUE EXPRESSED IN SELECTED CURRENCIES[1]

Country (currency)	(Per pound U_3O_8 as Concentrates) December 31, 1988	March 31, 1989	June 30, 1989	September 30, 1989	December 31, 1989	December 31, 1989 Related to December 31, 1988
Australia (dollar)	13.76	13.06	12.98	12.42	11.33	- 17.7%
Belgium (comm. franc)	437.00	423.80	401.80	379.30	319.60	- 26.9%
Canada (dollar)	14.02	12.72	11.71	11.33	10.41	- 25.7%
EEC (ecu)	10.02	9.66	9.22	8.77	7.48	- 25.3%
Finland (markka)	48.82	45.45	43.29	41.27	36.30	- 25.6%
France (franc)	71.19	68.40	65.29	61.22	52.08	- 26.8%
Italy (lira)	15,351	14,845	13,917	13,149	11,390	- 25.8%
Japan (yen)	1,469	1,421	1,408	1,347	1,296	- 11.8%
The Netherlands (guilder)	23.59	22.83	21.66	20.39	17.17	- 27.2%
South Africa (comm. rand)	27.80	27.26	27.09	26.27	22.83	- 17.9%
Spain (peseta)	1,331	1,262	1,223	1,155	985.11	- 26.0%
Sweden (krona)	71.91	68.89	65.29	61.98	55.83	- 22.4%
Switzerland (franc)	17.64	17.70	16.50	15.65	13.90	- 21.2%
UK (pound)	6.50	6.35	6.34	5.96	5.62	- 13.5%
US (dollar)	11.75	10.65	9.80	9.60	9.00	- 23.4%
West Germany (mark)	20.84	20.25	19.22	18.06	15.23	- 26.9%

[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month indicated.

MARKET DEVELOPMENTS

U3O8, well below the then-current Australian uranium floor price. Despite the lower price, one West German utility did cancel its ERA contract. Another terminated its contract to purchase ERA material from an intermediary. Although the government has not made any explicit statement to this effect, it clearly has abandoned its rigid floor price policy in favor of a more flexible approach. However, at year-end it was not clear when or if the three mine policy might be amended.

Later in 1989, West Germany's Federal Ministry of Research and Technology (BMFT) sold 100 million Deutschemarks ($55 million) worth of its natural and enriched uranium stockpile to Nukem, a West German nuclear fuel trader. The BMFT sale was the year's largest inventory liquidation. But notwithstanding its very real impact on available supply, the sale's psychological impact was even more important. During the latter part of the year, it dominated market psychology. Awareness of the BMFT material's presence in the market heightened the perception that the existing uranium supply glut would be sustained in the face of unusually heavy spot market buying activity.

Namibia steadily moved toward independence from South Africa, fueling expectations that political barriers to the purchase of its uranium would fall soon. Although this had no immediate impact on the spot market, it did contribute to the perception of a continuing uranium oversupply. Namibia held its first national election in November under United Nations' supervision. The country elected a Constituent Assembly to draft a constitution, which was completed in early 1990. Namibia gained its independence on March 21, 1990. Canada and the USA immediately lifted their sanctions against Namibian uranium, and other sanctions should fall shortly as well. Some buyers may even favor Namibian-origin uranium in order to support the newly independent nation's economy.

Three US reactors (Shoreham, Rancho Seco, and Fort St. Vrain) were retired, and the Austrian utility GKT sought

Table 4
1989 ACTIVE URANIUM SUPPLY AND DEMAND

Determined as of the last day of the Month	Published in Report Number	Supply	Demand	Supply/ Demand Ratio
		(Thousand Pounds Equivalent U_3O_8)		
January	246	8,665	1,245	7.0
February	247	6,225	3,065	2.0
March	248	3,770	1,070	3.5
April	249	4,825	1,270	3.8
May	250	3,455	1,515	2.3
June	251	3,500	1,960	1.8
July	252	4,355	2,585	1.7
August	253	4,230	3,365	1.3
September	254	5,180	4,510	1.2
October	255	7,880	5,855	1.3
November	256	8,310	2,645	3.1
December	257	4,835	1,750	2.8
Annual Averages [1]		**5,436**	**2,570**	**2.7**

[1] Simple arithmetic averages.

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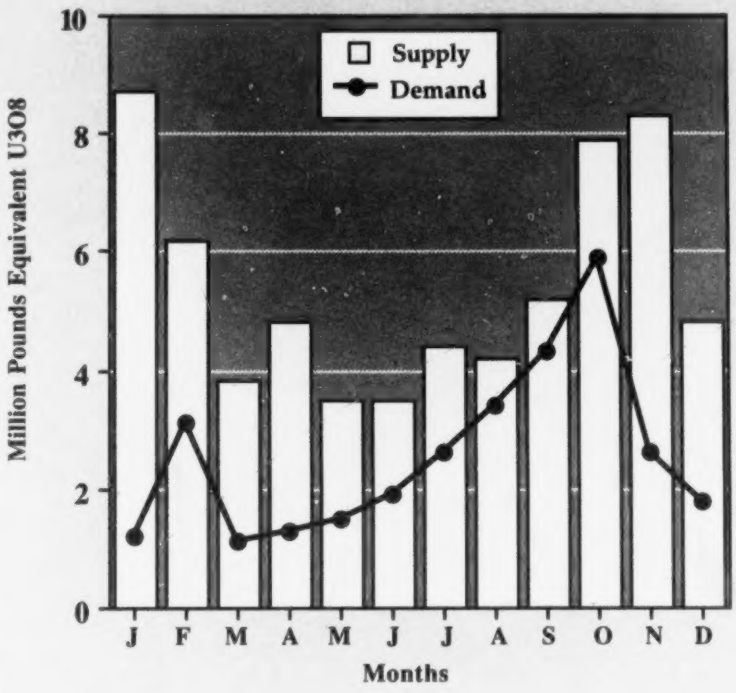
bids for its last remaining inventory, thereby liberating substantial quantities of fabricated fuel and natural uranium in 1989 and early 1990. The Philippines sought offers for its fabricated fuel at year-end, although no offers met the Philippines' unrealistically high minimum bid requirement. A number of other utilities in Europe and the USA either sold or loaned their excess material as part of revised procurement and inventory holding strategies.

Suppliers' aggressive competition for each new sales opportunity spurred further price declines.

The Soviet Union, through its nuclear fuel marketing agency Techsnabexport (TENEX), actively sought to augment its international business by making enriched uranium product (EUP) sales during 1989. The emergence of TENEX as a supplier of uranium in addition to SWU, also contributed to widespread perceptions of ample supply.

Figure 1
COMPARISON OF 1989 ACTIVE SUPPLY AND DEMAND



Demand

Once again in 1989, discretionary demand accounted for a preponderance of buying activity, as buyers sought to take advantage of historically low prices. Most bought natural uranium concentrates and little firm demand for UF6 materialized. This year differed substantially from recent years in that fewer buyers insisted on specific origins. Activity intensified early and late in the year, at times when many market participants anticipated the market bottoming.

Intermediaries made up the largest buying group, although producers became increasingly active towards year-end. The low spot prices also induced many producers to make discretionary purchases, and in early 1990, one primary producer began purchasing large quantities of natural uranium in an effort to meet near-term delivery requirements, as well as, presumably, to reduce the supply glut.

A number of utilities solicited offers publicly and signed multiple supply contracts in both the near-term and longer-term markets. As in the past, buyers sought multiple suppliers to spread the risk of supply disruptions.

During 1989, active demand for uranium averaged 2.6 million pounds monthly, ranging from 1.1 to 5.9 million pounds equivalent U_3O_8 (**Figure 1**). The monthly supply/demand ratios for 1989 averaged 2.7 to 1. However, the ratio of average supply (5.4 million) to average demand (2.6 million) is 2.1 to 1.

Transaction Value

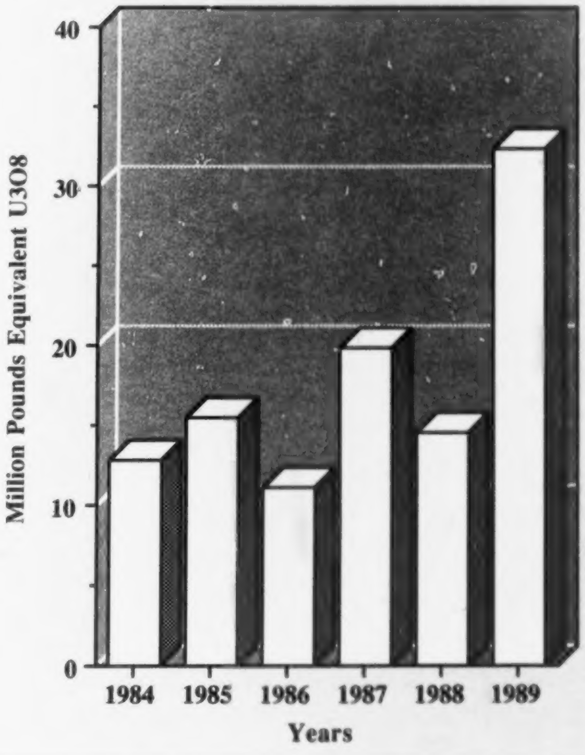
NUEXCO's Transaction Value (TV) is a weighted average of prices paid for natural uranium in recent spot and near-term sales meeting certain criteria (**Table 2**). In

1989, the TV fell 25 percent from $12.25 per pound equivalent U_3O_8 at December 31, 1988 to $9.40 at December 31, 1989 (**Table 1**). As in the past, the TV trailed the declining Exchange Value, which fell by 23 percent over the year.

During the first half of the year, the TV trailed the Exchange Value by $0.50 to $0.90. This differential decreased after June, however, when the Exchange Value paused at $9.80 for two months; thereafter, both Values began declining at a somewhat slower rate.

The Transaction Values for January 31, 1989 through December 31, 1989 included a total of 81 sales that took place in 1989 (compared to 74 in 1988), and a total quantity of 16.0 million pounds equivalent U_3O_8 (11.4 million in 1988). The 1989 weighted average annual Transaction Value was $10.34. Note that this average is not found simply by averaging all twelve monthly Transaction Values. The weighted average counts each transaction only once; it also excludes any 1988 sales included in TV calculations for early 1989. The sum of the quantities sold in these transactions is then divided into the sum of price times quantity calculations, giving a weighted average for the 1989 transactions included in the Transaction Value.

Figure 2
SPOT AND NEAR-TERM URANIUM SALES VOLUME (1984-89)



Transaction Analysis

Spot and Near-term Sales

For 1989, NUEXCO reports 107 spot and near-term sales of uranium contained in concentrates, natural UF_6, and enriched UF_6, totalling almost 33 million pounds equivalent U_3O_8 (**Figure 2**). This represents a 33-percent increase in the number of sales from 1988 (81), and approximately a 120-percent increase (17.7 million more pounds) in volume. The 1989 figures include all 1989 transactions reported in Monthly Report Numbers 246-257, eight transactions occurring in late 1989 that were reported in early 1990, and seven other transactions not previously reported. NUEXCO's reporting of nuclear fuel transactions is subject to some limitations, and transactions which may not have been reported in 1989 include the following:

◆ Transactions (or certain information about published transactions) which, if reported, would jeopardize client confidentiality;

◆ Transactions about which insufficient reliable information was available;

◆ New deliveries, or the exercise of options for additional material, under old contracts (not considered to be new contracts);

◆ Transactions involving material other than concentrates, natural UF_6, or enriched uranium product (EUP);

◆ Transactions involving back-to-back sales (Generally only one transaction is reported in this case; however, when trading activities are involved, two transactions may be reported separately if available information warrants.);

◆ Transactions for exchanges of origin, location, form, or other commercially important attributes.

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Natural uranium concentrates comprised about 75 percent of the material sold for spot and near-term delivery in 1989 (**Table 5**). That constitutes a significant increase from last year's 62 percent. Sales of natural UF_6 accounted for 16 percent (27 percent in 1988), and EUP sales accounted for 9 percent (10 percent in 1988). North American origin characterized most of the concentrates sold in 1989. **Table 6** shows the same data aggregated by seller and buyer.

The Buyers — Intermediaries displaced utilities as the primary uranium buying group in 1989, purchasing approximately 47 percent of the material sold for near-term delivery (**Figure 3**). (Intermediaries include traders and other entities acting as traders.) Utilities, which bought about 86 percent of all uranium the previous year, accounted for only 44 percent of purchases in 1989.

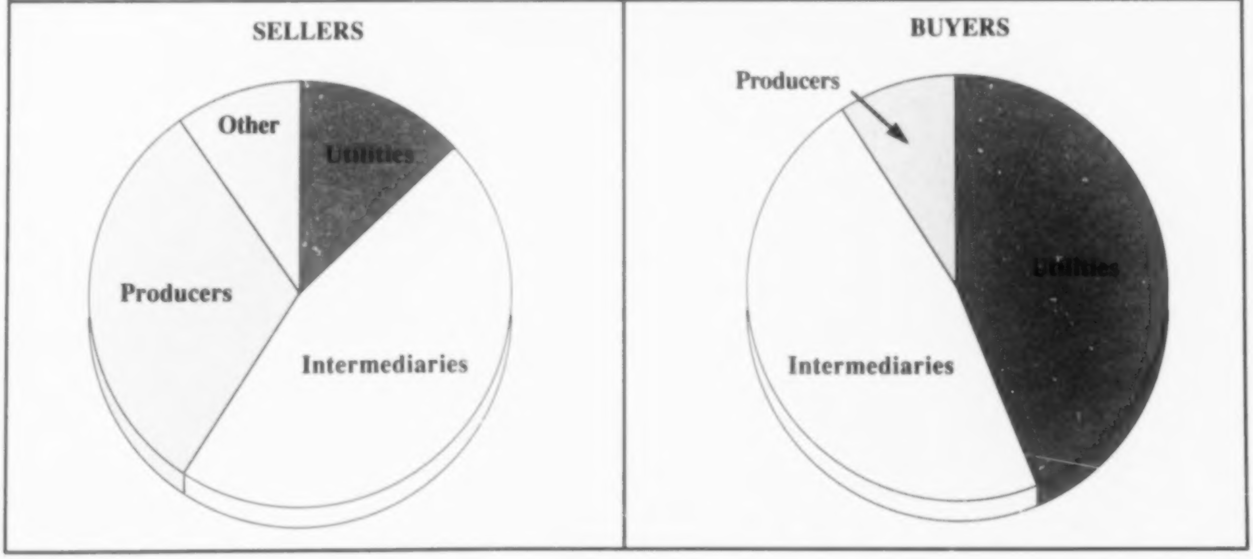
Intermediaries purchased approximately 15.3 million pounds equivalent U_3O_8, 11.5 million pounds in the form of concentrates. Utilities purchased a total of 14.2 million pounds equivalent U_3O_8, almost 70 percent as natural uranium concentrates. Producers bought the remaining 2.8 million pounds, all as concentrates for near-term delivery. Producer buyers accounted for 12 percent of near-term sales volume.

Table 5
FORM OF MATERIAL SOLD FOR SPOT AND NEAR-TERM DELIVERY
Percent Share (1985-1989)

	1985	1986	1987	1988	1989
Concentrates	67.1	42.2	57.0	62.3	74.8
Natural UF_6	31.6	51.0	35.5	27.4	15.9
Enriched UF_6	1.3	6.8	7.5	10.3	9.3
Total	100.0	100.0	100.0	100.0	100.0

US entities bought over 16 million pounds equivalent U_3O_8 in 60 transactions, followed by European entities which purchased over 15 million pounds in 45 transactions. Far Eastern entities bought little in 1989, as several Japanese utilities had concluded long-term contracts with US producers at the end of 1988. South Korea also temporarily withdrew from the market and commissioned a study on long-term procurement strategies.

Figure 3
1989 SELLERS AND BUYERS
SPOT AND NEAR-TERM URANIUM TRANSACTIONS
(Percent Share by Volume)



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MARKET DEVELOPMENTS

Table 6
ANALYSIS OF 1989 SPOT AND NEAR-TERM URANIUM SALES

	Concentrates		UF_6		Enriched Uranium Product		Total	
SALES BY	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8
PRODUCERS to:								
Utilities	9	2.2	1	0.3	–	–	10	2.5
Producers	6	0.6	–	–	–	–	6	0.6
Intermediaries	13	6.6	–	–	1	0.4	14	7.0
Total	**28**	**9.4**	**1**	**0.3**	**1**	**0.4**	**30**	**10.0**
UTILITIES to:								
Utilities	–	–	1	0.3	–	–	1	0.3
Producers	2	0.2	–	–	–	–	2	0.2
Intermediaries	9	3.6	–	–	–	–	9	3.6
Total	**11**	**3.8**	**1**	**0.3**	**–**	**–**	**12**	**4.1**
INTERMEDIARIES to:								
Utilities	27	7.6	12	2.5	3	1.2	42	11.3
Producers	7	2.1	–	–	–	–	7	2.1
Intermediaries	8	1.3	1	0.3	–	–	9	1.6
Total	**42**	**10.9**	**13**	**2.8**	**3**	**1.2**	**58**	**14.9**
OTHER ENTITIES to:								
Utilities	–	–	1	0.1	–	–	1	0.1
Producers	–	–	–	–	–	–	–	–
Intermediaries	1	0.1	3	1.6	2	1.5	6	3.2
Total	**1**	**0.1**	**4**	**1.7**	**2**	**1.5**	**7**	**3.3**
TOTAL	**82**	**24.1**	**19**	**5.1**	**6**	**3.0**	**107**	**32.3**

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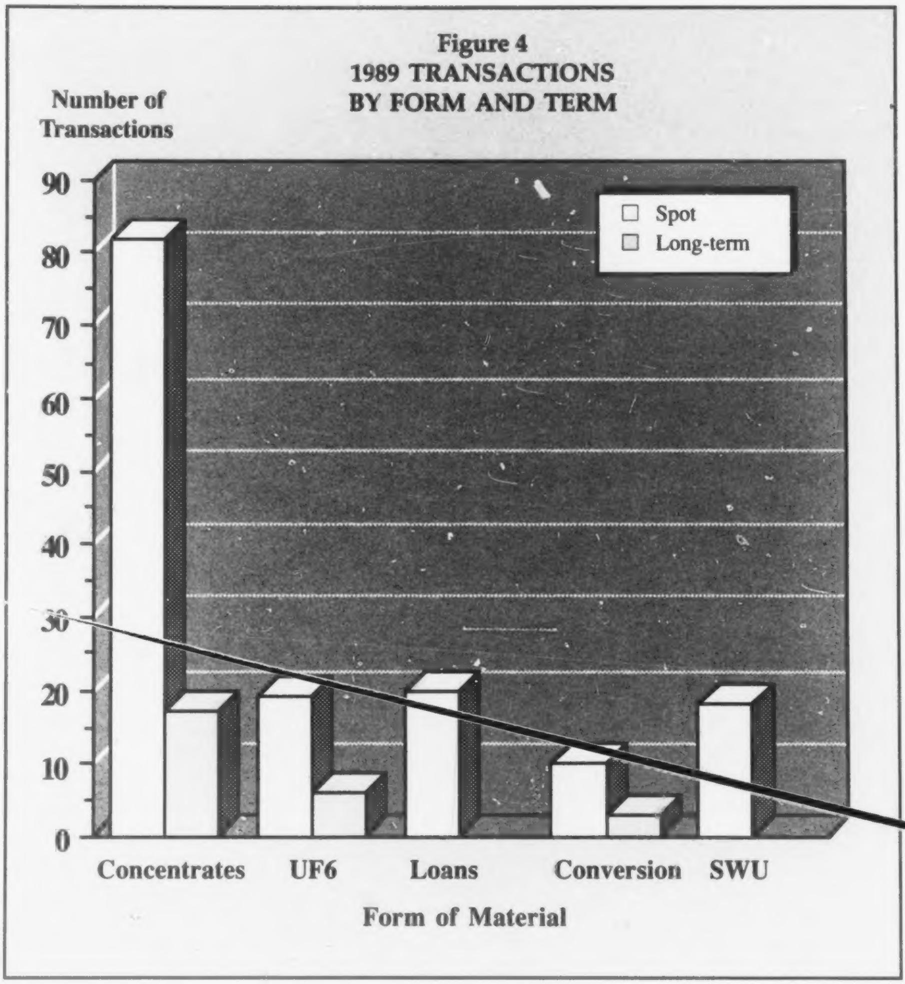
Figure 4
1989 TRANSACTIONS BY FORM AND TERM



The Sellers — Intermediaries also dominated as sellers in the 1989 spot market (**Figure 3**), but their 46-percent share of total sales volume was considerably reduced from the 1988 record of 61 percent. Producers sold over ten million pounds equivalent U_3O_8, about 30 percent of 1989's total volume. Utilities were much more active as sellers in 1989, accounting for almost 13 percent of all sales, in comparison to their two-percent share in 1988. However, the "Other" category, which includes government entities, fabricators, enrichers, and converters, accounted for about ten percent of total sales volume.

US entities acted as sellers in 73 transactions, accounting for almost 63 percent of the total near-term uranium sales volume. European entities sold almost one-third of all uranium, and a Far Eastern entity accounted for the remainder. Canadian and Australian producers sold little in the spot market in 1989.

Long-Term Sales

NUEXCO reports 23 long-term uranium sales for 1989, seventeen involving concentrates and six involving natural UF_6 (**Figure 4**). No long-term enriched uranium sales are reported. These 23 transactions accounted for approximately 34 million pounds equivalent U_3O_8. Producers sold the bulk of material—about 75 percent—most of which was in the form of concentrates. Intermediaries sold the remaining 25 percent.

Utilities bought about 22 million pounds equivalent U_3O_8, followed by producers at almost 8 million, and intermediaries at 4 million pounds. Uranium of North American origin made up almost 70 percent of all material sold in long-term transactions.

While many utilities continued to insist that deliveries under long-term contracts be linked to spot-market prices, others, preferring escalated base prices, saw 1989 as a good time to obtain new, long-term contracts with sharply lower base prices—in the range of $13-$15 per pound.

Ten long-term transactions contained market-related pricing terms, six contained fixed prices, and three contained escalated base prices. Price terms of the remaining four sales are not reported. Little long-term nuclear fuel contracting occurred in Western Europe during 1989.

Uranium Loans

The Loan Rate remained at 3.5 percent per annum throughout 1989, unchanged since November 1987. In addition to the excess material for sale, the ample inventories available for loan added to the worldwide uranium glut. Utilities were the primary lenders, while most of the borrowers were intermediaries, followed by producers preferring to borrow rather than produce to fill delivery commitments.

During 1989, a number of EUP loans also took place. The loans were made primarily to take advantage of loan rates which were significantly lower than the cost of money. Utilities were the primary lenders, while both intermediaries and utilities were the borrowers.

Lending activity increased substantially in 1989. Twenty loans involving 8.8 million pounds U_3O_8 equivalent were reported, compared to eight loans for a total of 2.0 million pounds in 1988.

CONVERSION SERVICES

Prices for conversion services, as indicated by the NUEXCO Conversion Value, fell approximately 15 percent in 1989, from $1.95 per pound U as UF_6 at December 31, 1988, to $1.65 at the end of December (**Table 7**). Although the NUEXCO Conversion Value by definition applies to the secondary market, aggressive competition for all types of conversion sales by the primary converters caused the price differential between the primary and secondary conversion markets to diminish during 1989.

NUEXCO reports 15 conversion sales occurring in 1989, 12 involving near-term delivery and three for the longer-term. Converters sold approximately 83 percent of all the conversion services, while intermediaries accounted for essentially all of the remaining sales. Utilities purchased the bulk of conversion services—86 percent—while intermediaries, one utility, and one producer accounted for

Table 7
1989 NUEXCO
CONVERSION VALUE AND SWU VALUE
(as of the last day of the month indicated)

Determined as of the Last Day of the Month	Report Number	Conversion Value Per Pound U as UF_6	Conversion Value Per Kg U as UF_6	SWU Value (Per SWU)
January	246	$1.95	$4.30	$65
February	247	$1.95	$4.30	$67
March	248	$1.95	$4.30	$67
April	249	$1.95	$4.30	$67
May	250	$1.95	$4.30	$66
June	251	$1.95	$4.30	$66
July	252	$1.95	$4.30	$66
August	253	$1.90	$4.19	$65
September	254	$1.90	$4.19	$63
October	255	$1.80	$3.97	$59
November	256	$1.75	$3.86	$57
December	257	$1.65	$3.64	$54
***1989 Averages*[1]**		**$1.89**	**$4.16**	**$64**

[1] Simple arithmetic averages.

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the balance. The oversupply in the uranium markets, particularly enriched and natural UF6, contributed to the falling prices for conversion services.

ENRICHMENT SERVICES

Spot Market Prices

Prices for secondary market enrichment services (SWU), as indicated by the NUEXCO SWU Value, fell 17 percent in 1989, from $65 to $54 per SWU (**Table 7**). Most of this decline occurred in the second half of the year. There was little projected demand for SWU in early 1989, and supply remained abundant. Among the major suppliers, TENEX offered SWU at spot market prices for the first half of the year, and BMFT sold part of its stockpile of enriched uranium in the second half of 1989. Enriched uranium inventories from several canceled plants also contributed to available supply and put downward pressure on prices.

The NUEXCO SWU Value actually rose in early 1989, beginning at $65 in January, and rising to $67 per SWU for the next three months. It dropped modestly to $66 per SWU through July, then declined steadily each month thereafter, ending the year at $54 per SWU. The downturn began when both buyers and sellers became convinced that the BMFT stockpile would be sold on the spot market, and continued as it became clear that the material was being aggressively marketed.

Transaction Analysis

NUEXCO reports 18 spot and near-term sales of SWU and SWU contained in EUP in 1989, totalling about 1.8 million SWU. In terms of market volume and number of transactions, the SWU market was little changed from 1988. However, the 1989 SWU market was characterized by more complex transactions among enrichers, inventory holders, intermediaries, and end users. For 1989, NUEXCO reports sales to end users involving 400,000 SWU for near-term delivery, which was balanced by an equivalent amount sold by enrichers and inventory holders. However, most sales involved intermediaries, who resolved location, timing, assay, origin, and quantity mismatches.

Approximately half of the SWU changed hands in sales of enrichment services, in which the seller exchanged enriched uranium for natural uranium plus cash. The remainder of the SWU sales are more accurately described as enriched uranium transactions. Buyers were about evenly split between the USA and Europe.

As anticipated early in 1989, BMFT announced in June that it was selling part of its inventories of enriched and natural uranium. BMFT chose to sell a total of DM100 million ($55 million) worth of material in 1989 and 1990 to supplement its budget. BMFT also held discussions with DOE about the possible sale of the remainder of the stockpile in 1991 and later. DOE received permission from the US Congress to purchase the BMFT stockpile, to the extent that the purchase resulted in net cost savings. However, no agreement had been reached by year-end.

Marketing by the Soviet Union (TENEX)

During 1989, TENEX announced that its export sales of enrichment services were based on the Soviet Union's excess centrifuge capacity of ten million SWU per year, more than triple the level previously thought available by most Western experts. Half of that excess is reserved for export. The Soviet Union's first pilot centrifuge plant produced SWU in 1952, and its first industrial plant began operating in 1957. The Soviet Union has curtailed its domestic nuclear power program since the Chernobyl accident, resulting in capacity surpluses and excess inventories.

Recent political developments in the Soviet Union made the purchase of Soviet SWU and EUP more attractive to Western utilities. At the end of 1989, TENEX had reached an agreement to place a stockpile of EUP at two US fuel fabricators. The stockpile is intended to facilitate sales of Soviet material in the USA by eliminating any concerns potential buyers may still have regarding the reliability of Soviet supply.

US Department of Energy (DOE)

DOE has projected production of 12.2 million SWU in Fiscal Year (FY) 1990, nearly twice the 6.4 million SWU planned for FY1989. DOE's two operating gaseous diffusion plants have a total capacity of about 19 million SWU per year, so its average plant utilization factor will go from about 35 percent in FY1989 to 65 percent in FY1990. Operation at the higher level of production will more than double projected power costs, from $285 million to $631 million, because more SWU will be produced during peak

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power periods, which carry higher unit costs for power. The average cost per SWU was projected to rise from $44.50 in FY1989 to $51.70 per SWU for FY1990.

DOE requested a special $55 million appropriation from Congress in order to fund the purchase of additional power in FY1989 to preproduce about one million SWU for delivery in FY1990. DOE was trying to take advantage of lower production levels in 1989, when it could buy additional off-peak power for about $30 per SWU. The cost to produce the same amount of SWU in FY1990 was projected to be $120 million. However, DOE received congressional approval too late for it to actually preproduce the SWU.

Throughout the year, DOE continued to operate its diffusion plants at tails assays higher than the transaction tails assays chosen by customers. DOE obtained the extra uranium needed for this overfeeding from its natural uranium inventories. The overfeeding process allowed DOE to reduce its cash outlay for power, while also reducing the accrued cost of maintaining the inventory. DOE plans to continue the overfeeding program until its uranium inventory is eliminated.

In February, DOE announced that the FY1990 enrichment price under its Utility Services Enrichment Contract (USEC) would be raised to $122 per SWU, up from $117 in FY1989. The USEC ceiling price is partially determined by DOE's average power costs in the second quarter of the previous year. When finalized later in the year, it was lower than expected, so DOE's price increase was limited by the ceiling to less than one dollar. The final FY 1990 price was $117.85.

April 1, 1989 was the deadline for DOE customers to submit notices for free termination of FY1999 deliveries under the USEC. DOE received notices from 19 customers terminating 2.7 million SWU, or about 20 percent of its planned sales for that year. This was more than double the nine customers who sent in termination notices in 1988. Most customers who terminated indicated they did so to reduce the length of their enrichment commitments; they did not plan to contract for 1999 deliveries in the near future. However, concerned about additional terminations, DOE notified customers in early 1990 that the filing of their notices of free termination for the year 2000 could be delayed by one year, until April 1, 1991.

In 1989, DOE continued to press for legislation which would restructure the enterprise into a government corporation having greater flexibility and thus would be better able to compete. In 1988, legislation that would have accomplished DOE's goals and also addressed the uranium tailings issue had passed the Senate, but had failed to pass in the House of Representatives. In 1989, similar legislation again passed the Senate, but again failed to gain support in the House. A lack of consensus in defining the major issues has prevented the House from moving forward.

DOE and the US fabricators attempted to introduce a new concept called SWUFLEX, which would allow DOE customers both reduced product assay notification deadlines and reduced feed delivery leadtimes for SWU taken at a few standardized enrichments. However, the inability of DOE, the fabricators, and the utilities to agree on how to divide the benefits of the program prevented its implementation. At the end of the year, DOE introduced a scaled-down program that reduced its standard 180-day notice period to 120 days for its standard enrichments.

Eurodif

During 1989, Eurodif held negotiations on enrichment contracts with its shareholders in Belgium, France, Italy, and Spain. Although its Italian shareholders (ENEA and Agip SpA) did not seek additional long-term SWU supplies because of Italy's nuclear moratorium, Eurodif reached new supply agreements for the early 1990s with Cogema (in conjunction with Electricité de France), Synatom (of Belgium), and ENUSA (of Spain). Eurodif has a capacity to produce 10.8 million SWU per year. Cogema acts as the international marketing agent for the Eurodif consortium.

Urenco

Urenco's installed centrifuge enrichment capacity at the end of 1989 amounted to approximately 2.4 million SWU. The oldest plant, located at Almelo, The Netherlands, and operated by UCN (Ultra-Centrifuge Nederland N.V.), has a current annual capacity of about 1.2 million SWU. The plant at Capenhurst, United Kingdom, operated by British Nuclear Fuels plc. (BNFL), has a capacity of 800 thousand SWU per annum, while the newest plant at Gronau, West Germany, has an annual capacity of about 400 thousand SWU. The additions to Urenco's installed enrichment capacity are made by adding modules at the various plant sites. Urenco's principal enrichment contracts are held with West German, Dutch, and British utilities, as well as a handful of other European and US utilities.

Urenco and four US partners announced plans in June 1989 to build a 1.5 million SWU-per-year enrichment facility in the USA using Urenco's enrichment technology. The US partners in the joint venture, called Louisiana Energy Services (LES) are Duke Power, Graystone (Northern States Power), Louisiana Power and Light, and Fluor Daniel, Inc., the architect-engineer-constructor. The planned cost of the facility is $750 million, including financing costs. Operation is scheduled for 1996.

Enrichment Technologies

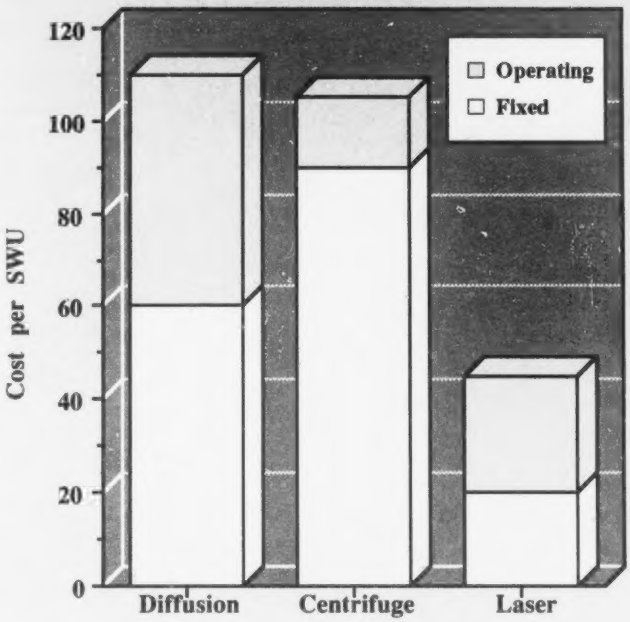
Three uranium enrichment technologies are currently in competition for commercial utilization—gaseous diffusion, the centrifuge, and lasers. Each technology has a different cost structure, as shown in **Figure 5**.

Gaseous Diffusion

Gaseous diffusion technology is by far the most utilized and developed of the enrichment technologies. The capital costs of DOE's diffusion plants have essentially been written off, while those of Eurodif are expected to be fully depreciated by the mid-1990s. However, during 1989, it became obvious that DOE's diffusion plants would become less competitive as a result of future costs associated with clean air legislation.

Most experts believe that the gaseous diffusion plants used by DOE and Eurodif will be in production through the end of the century, but eventually, because of the enormous electricity requirements of this technology, probably will not be able to compete with more energy-efficient methods. DOE announced that proposed acid rain legislation (Clean Air Act) in the USA could increase production costs at the gaseous diffusion plants by $15 per SWU, because the power plants that supply power to DOE's plants primarily burn high-sulfur coal. DOE estimated that the proposed legislation would increase electric power costs (exclusive of demand charges) from about $55 per SWU to $70 per SWU, increasing total production costs from about $75 to $90 per SWU.

Figure 5
PRODUCTION COSTS OF DIFFERENT ENRICHMENT TECHNOLOGIES
(in Constant 1989 US Dollars)



China announced during 1989 that it would cease enrichment for military purposes, and its gaseous diffusion enrichment facilities would be dedicated to civilian use. However, with ongoing power shortages in China, it is not expected that China will be an aggressive exporter of enrichment, because of the need to conserve electricity for domestic use.

Centrifuge

Centrifuge technology has substantially lower operating costs than gaseous diffusion, but capital costs have kept prices for centrifuge SWU high in the Western world. The low operating cost of the centrifuge system means that centrifuge SWU could be sold at current spot market prices if the capital costs were already amortized. The Soviet Union's announcement in 1989 that it has utilized centrifuge production since 1957 provides a rational basis for its policy of pricing near secondary market levels, as its

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facilities are old enough to be completely amortized, and they represent incremental capacity to the Soviet Union.

Assuming that the charge to recover the initial capital cost (including a return on the investment) is 15% to 20% per year, the capital component of the LES Urenco SWU is projected to fall in the range of $75 to $100 per SWU. LES has projected operating costs in the range of $15 to $20 per SWU, and should not be as sensitive to electrical cost increases expected under amendments to the Clean Air Act now pending before Congress. Additional expansions of the LES capacity could result in even lower costs.

Japan has plans to build a pilot enrichment plant with advanced centrifuges using carbon-fiber reinforced plastic rotors. It is to have a capacity of 40,000 to 50,000 SWU per year and to be in operation in FY 1991; however, further development has been temporarily postponed after the election of an antinuclear mayor in Rokkasho-mura, the site of the pilot plant.

Laser

Lasers have the most economic promise, but are the least developed and the riskiest of the enrichment technologies. Questions remain whether laser enrichment will be commercialized by the national laboratories with their bureaucracies and high overhead, or by smaller, undercapitalized entrepreneurs.

DOE announced that the production costs of the first three million SWU-per-year AVLIS plant could be as much as $80 per SWU, including amortization of capital and development costs over 15 years. However, if the development costs were spread over additional capacity, the AVLIS process would be expected to come closer to the previous costs estimates of $45 to $50 per SWU.

DOE has recently announced a demonstration program for AVLIS, scheduled for completion in 1992, in a pilot facility capable of producing 100 thousand SWU per year. However, the program is dependent on increased government funding through FY1992.

Isotope Technologies, a small company based in Los Angeles, California, is marketing future production from its Chemical Reaction by Isotope Selective Laser Activation (CRISLA) enrichment process. The CRISLA technology utilizes UF_6 gas, giving it a potential economic advantage over DOE's AVLIS process, which uses uranium metal and would therefore require the development of a uranium metal fuel cycle. The separation properties of CRISLA have been tested on a laboratory scale, both in China and the USA, but have not yet been proven on a pilot scale.

Laser development is also underway in France through the SILVA program (the equivalent of DOE's AVLIS), conducted by the Commisariat à L'Energie Atomique (CEA). CEA funds all research and development on SILVA, and will license the technology to Cogema for deployment. This program is based on developing the capability for deploying SILVA in the late 1990s and lags the DOE AVLIS development program by about three years. The Soviet Union is also known to have substantial expertise with lasers.

MARKET OUTLOOK

In conclusion, many buyers and sellers thought, at the beginning of the year, that the decline of prices—concentrates, UF_6, EUP, conversion, and SWU—might finally run its course in 1989. The nuclear fuel market did see numerous changes during the year, but prices were still trending down at year-end. For that reason and others, the market looked essentially the same to potential buyers at the end of the year as it did at the beginning.

Inventories are being reduced every year, but they still substantially exceed aggregate desired levels. Despite a temporary easing of supply excesses in the concentrates market, buyers and sellers still expect overall supply excesses and aggressive competition for sales opportunities. Discretionary buyers still insist on low prices and favorable terms, confident that supply will be made available as necessary. If buyers and sellers see their expectations being met yet again, the cycle will continue. These same factors can be expected to continue driving the market until excess inventories are drawn down sufficiently to cause buyers and sellers to perceive imminent supply shortages. In the meantime, the market will continue to be dominated directly and indirectly by the continuing mobilization and redistribution, by sales, loans, and swaps, of heretofore frozen inventories. ■

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URANIUM PRODUCTION

In 1989, uranium production decreased by over five million pounds to about 89 million pounds equivalent U_3O_8 (**Table 8**), its lowest level since 1978. This supply reduction, however, was offset somewhat by increased exports from Eastern Europe and China—3 million pounds equivalent U_3O_8 in 1989, up from 1.3 million pounds in 1988. Uranium production fell substantially in Canada, Namibia, and South Africa, while output held steady or increased slightly in most other countries. A country-by-country summary of 1989 output follows, beginning with the largest uranium producing nations.

CANADA

Despite a reduction in 1989 output, Canada led the world in uranium production for the sixth consecutive year, with a total of 29.4 million pounds equivalent U_3O_8. The nine-percent decrease from the 1988 figure of 32.4 million pounds was due to production cuts at both the high-cost mines of Ontario and the low-cost mines in Saskatchewan.

At year-end, only the world's largest uranium producer, the Key Lake project, now managed by Cameco, operated in Saskatchwan; other Saskatchwan producers had suspended operations due to poor market conditions. Two major

Table 8
URANIUM PRODUCTION[1]
(1984-1989)

	Production (Million Pounds Equivalent U_3O_8)						1989 Production Relative to 1988	Market Share[2]	
	1984	**1985**	**1986**	**1987**	**1988**	**1989**		**1984**	**1989**
Australia	11.2	8.4	10.8	9.8	9.3	9.5	+ 2.2%	11.1%	10.7%
Canada	29.0	28.3	30.5	32.3	32.4	29.4	- 9.3%	28.8%	33.0%
France	8.2	8.3	8.5	8.6	8.3	8.4	+ 1.2%	8.2%	9.4%
Gabon	2.4	2.4	2.2	2.1	2.0	2.2	+ 10.0%	2.4%	2.5%
Namibia	9.6	8.8	9.0	9.2	9.1	8.0	- 12.1%	9.5%	9.0%
Niger	8.6	8.3	8.2	7.8	7.5	8.0	+ 6.7%	8.6%	9.0%
South Africa	14.9	12.7	12.0	10.3	9.9	7.6	- 23.2%	14.8%	8.5%
USA	14.7	11.1	13.7	12.5	13.3	13.5	+ 1.5%	14.6%	15.2%
Other[3]	2.0	2.0	2.1	2.4	2.4	2.5	+ 4.2%	2.0%	2.7%
Total	**100.6**	**90.3**	**97.0**	**95.0**	**94.2**	**89.1**	**-5.4%**	**100%**	**100%**

[1] Figures presented are NUEXCO's best estimates.

[2] Expressed as a percentage of total production.

[3] Includes Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, West Germany, and Yugoslavia.

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underground test mining projects were underway in 1989: Cigar Lake and Midwest.

USA

US uranium production during 1989 totalled 13.5 million pounds equivalent U_3O_8, up slightly from 13.3 million pounds in 1988. Conventional production methods accounted for 55 percent of US output, while by-product operations and in-situ leaching (ISL) contributed 27 and 18 percent, respectively.

AUSTRALIA

Australia produced 9.5 million pounds equivalent U_3O_8 in 1989, up two percent from 9.3 million pounds in 1988. Only the Ranger and Olympic Dam projects operated during 1989; Queensland Mines completed mining and milling at Nabarlek in 1988. Exploration and development continued, but slowly. Neither the uranium market nor Australian government policy provided any current incentive for further expenditures.

FRANCE

French uranium production remained essentially unchanged in 1989 at 8.4 million pounds equivalent U_3O_8, as compared to 8.3 million pounds the previous year. Cogema's four main facilities, Herault, La Crouzille, and Vendée, and Le Cellier produced 7.0 million pounds. Total Minerals' Cherbois contributed the balance of the year's production.

NAMIBIA

Namibia's uranium output decreased 12.1 percent to 8.0 million pounds equivalent U_3O_8 in 1989. However, increased production and sales are likely due to the country's newly attained independence (effective March 21, 1990). The annual capacity of Namibia's only producer, Rössing Uranium Ltd., is more than ten million pounds.

NIGER

Output in 1989 from Niger's two operating mines, Akouta and Arlit, increased by almost seven percent from 1988 levels, to 8.0 million pounds equivalent U_3O_8.

SOUTH AFRICA

From 1988 to 1989, South Africa's uranium production dropped 23 percent, from 9.9 to 7.6 million pounds equivalent U_3O_8. Low market prices, in combination with sanctions against the use of uranium from South Africa, have had a major negative impact on South Africa's uranium producers. At year-end only seven producers remained in operation: Bufflesfontein, ERGO, Freegold, Hartebeestfontein, Palabora, Vaal Reefs, and Western Areas.

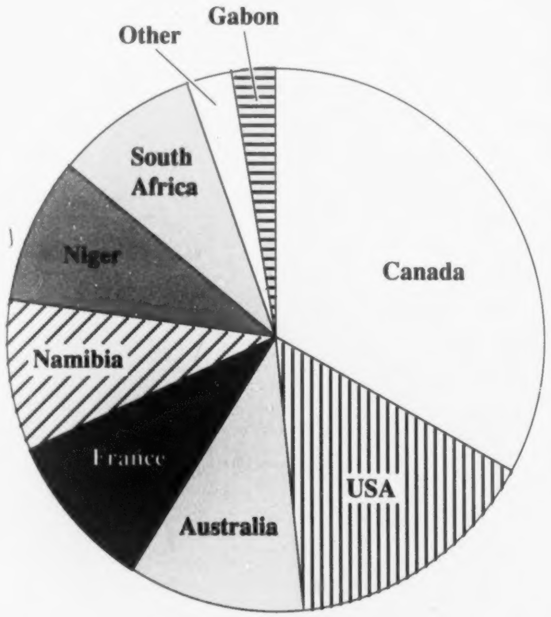
GABON

The Mounana mill produced 2.2 million pounds equivalent U_3O_8 in 1989 using ore from from Gabon's two uranium mines–Oklo and Boyindzi. This represents a ten-percent increase from 1988's output of 2.0 million pounds.

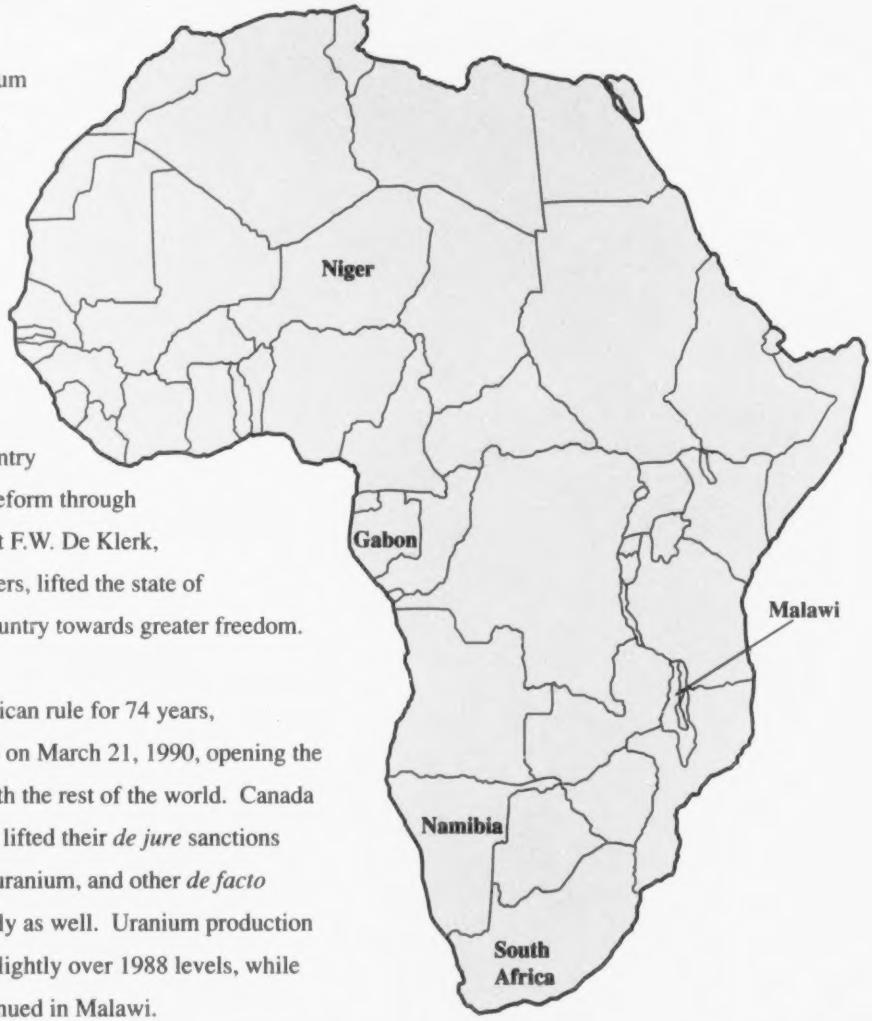
OTHER COUNTRIES

Argentina, Brazil, India, Pakistan, Portugal, Spain, West Germany, and Yugoslavia produced a total of approximately 2.5 million pounds equivalent U_3O_8 in 1989. Chinese and Soviet uranium made available to the commercial nuclear fuel market accounted for an additional three million pounds of available supply in 1989; however, detailed production figures were not disclosed. ■

Figure 6
1989 URANIUM PRODUCTION



AFRICA



Faced with anti-apartheid sanctions, declining uranium prices, domestic inflation, and rising costs associated with gold mining, South Africa's uranium production declined 23 percent from 1988. Despite depressed conditions in the mining sector, the country moved towards political reform through the leadership of President F.W. De Klerk, who freed political prisoners, lifted the state of emergency, and led the country towards greater freedom.

Namibia, under South African rule for 74 years, achieved its independence on March 21, 1990, opening the door to increased trade with the rest of the world. Canada and the USA immediately lifted their *de jure* sanctions against Namibian-origin uranium, and other *de facto* sanctions should fall shortly as well. Uranium production in Gabon and Niger rose slightly over 1988 levels, while uranium exploration continued in Malawi.

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GABON

Comuf (Compagnie des Mines d'Uranium de Franceville) produced about 2.25 million pounds equivalent U_3O_8 during 1989. That figure represents a ten percent increase from the 1988 output of about 2.0 million pounds. All uranium produced is exported via the new terminal at Owendo, near Gabon's capital of Libreville.

Comuf operates two mines–Oklo and Boyindzi–the output of which is processed at the Mounana mill, which has a capacity of about 4.3 million pounds equivalent U_3O_8. Although Comuf's high-cost output could not be sold profitably at current spot market prices, sales to France are made at substantially higher level. Due to a reduction in average grade of the ore being mined, output for 1990 is likely to decline by about 15 percent, to 1.9 million pounds equivalent U_3O_8.

Political Factors in Uranium Marketing

French entities control about 75 percent of Comuf and the Gabonese government holds the balance (**Table 9**). Gabon's government encourages foreign investors with its policy of economic liberalism, even though the government actively participates in all facets of the economy. The government offers various tax incentives for uranium exploration to a number of groups. The Leyou-North Joint Venture is made up of Cogema, the Gabonese government, and Korea Electric Power Company (KEPCO); the Franceville-South Joint Venture includes Cogema, the Gabonese government, Urangesellschaft, and Comuf, which also explores independently.

Membership in the Franc Zone gives Gabon considerable stability. The CFA (Communauté Financière Africaine) franc is automatically convertible to French francs at a fixed rate, giving trading partners confidence in Gabonese currency. Thus, while uranium exports are important for domestic employment and for the nation's balance of payments, Gabon does not depend on uranium as a primary source of foreign exchange.

Although purchases from Comuf are economically disadvantageous from the French perspective, reduction or cancellation of those purchases would be politically difficult. To do so would also reduce or eliminate an element of France's influence over Gabon. Such a move would not be undertaken without full consideration of its foreign policy implications.

Table 9
COMUF OWNERSHIP

Gabon Government	24.8%
Compagnie Française de Mokta (Cogema)	39.0%
Cogema	18.8%
Uranium Pechiney	10.6%
Cofimer	5.8%
Gabonese Individuals	1.0%
Total	100%

MALAWI

Although Malawi has no uranium production, it does have one noteworthy uranium deposit. The UK's Central Electricity Generating Board (CEGB, now Nuclear Electric) has an exclusive prospecting license for the Kayelekera uranium deposit, located in a sandstone host about 30 kilometers west of Karonga in northern Malawi. The field program of study was concluded during 1988, and CEGB has commissioned a feasibility study which is scheduled for completion in mid-1990.

Any possible exploitation of this deposit would necessarily be many years away primarily due to poor market conditions, and partially because Malawi has a very limited mining industry—labor intensive and very little mechanization—and a tiny industrial base. Although Malawi enjoys political stability and reasonable economic stability, it is one of the smaller countries in sub-Saharan Africa. Virtually all essential commercial and industrial needs must be imported, so that factor alone would greatly increase development times and costs.

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NAMIBIA

Namibia's progress toward independence was the most important development in Southern Africa during 1989. The governments of South Africa, Cuba, and Angola signed a treaty on December 22, 1988 granting independence to Namibia, until then a disputed South African territory also known as South West Africa. The implementation of the settlement in accordance with United Nations Security Council Resolution 435 began on April 1, 1989.

In the first Namibian elections, held November 7-11, the South West Africa People's Organization (SWAPO) won a majority of seats in the constituent assembly, but fell short of the two-thirds majority that would have allowed it to write its own constitution and take complete control. In December, the assembly agreed in principle on a constitution.

The agreed principles are essentially the same as those established in a 1982 supplement to UN Resolution 435, and are based on a multi-party democracy. They call for executive, legislative, and judicial branches to be governed by the constitution, and provide for certain human rights and individual freedoms. Namibia's constitution has been approved by the constituent assembly, and ratified by the UN Security Council.

Although the US State Department agreed that US sanctions should have been lifted after the "free and fair" election, that would have required special action by Congress, action which would not have met with universal approval. The USA, in accordance with the Comprehensive Anti-Apartheid Act of 1986, automatically lifted sanctions against Namibian uranium upon the country's March 21, 1990 independence. Canada also lifted its ban on new contracts for the conversion of Namibian origin concentrates.

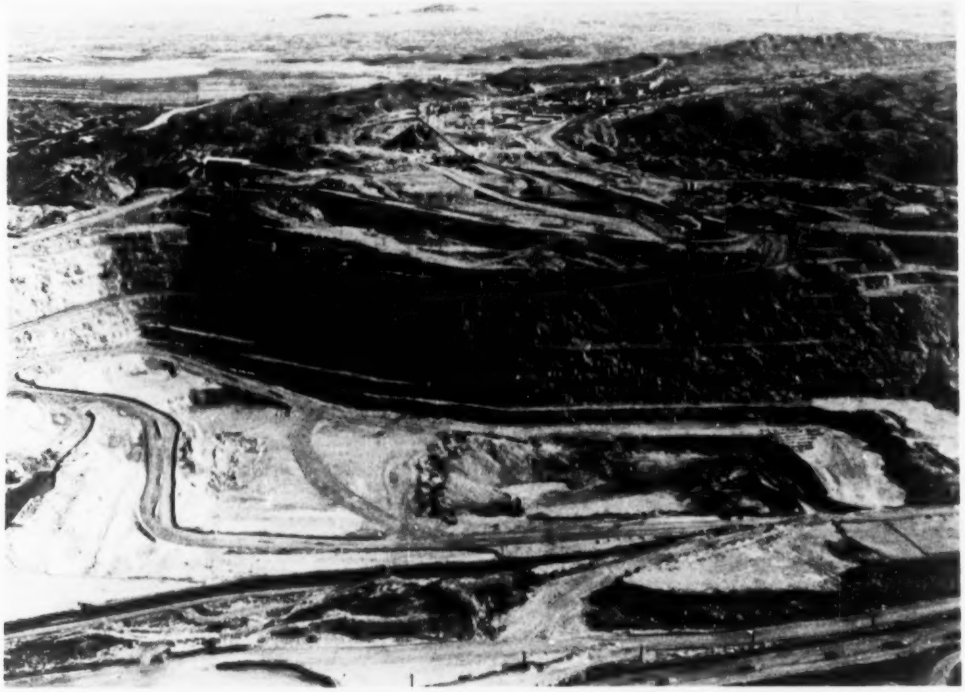

Figure 7. The Rössing open-pit mine in Namibia *(Photo courtesy of Rössing)*

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Other nations' sanctions against Namibia, and some individual customers' internal policies against doing business with Namibian concerns or buying Namibian products, should be removed promptly as well. When that happens, Namibian uranium will become politically acceptable throughout the market. It even could be favored by countries interested in supporting the newly independent nation's economy.

Marketing and sales are handled by the UK's RTZ Corporation, the leading shareholder in Rössing Uranium Ltd. (RUL). In giving pre-election assurances to Namibian mining interests, most notably RTZ, SWAPO indicated that it had moderated its earlier desire for widespread post-election nationalizations. SWAPO seemed to recognize that nationalization of such assets could jeopardize the country's economy, given that mining accounts for one-third of its entire economic output and fully 80 percent of Namibian exports. SWAPO's moderated stance is holding firm so far.

Uranium Production

Namibia's Rössing project (**Figure 7**) produced 8.0 million pounds equivalent U_3O_8 in 1989, down twelve percent from 9.1 million pounds in 1988. For the past several years, during the period of strongest anti-apartheid sanctions, Rössing has produced at relatively high levels, in order to retain its skilled work force and maintain its reputation as a reliable supplier.

The new Namibian government will have a 51-percent voting share in RUL. Although it will have only a 3.5-percent shareholding in RUL, it will have the majority voice in how the company is run. Rössing is the major employer of the country, and the new national leaders will be looking to Rössing to help improve economic health and employment. Given its annual capacity of more than ten million pounds equivalent U_3O_8, Rössing is likely to increase its production and sales substantially in 1990.

NIGER

Niger's two uranium production facilities yielded a total of about eight million pounds equivalent U_3O_8, a seven-percent increase from 1988's output of 7.5 million pounds. The Akouta facility (owned by Cominak) produced approximately five million pounds, and Somair's Arlit production center was responsible for the balance of the output.

◆ Akouta, the world's largest underground uranium mine, is owned by Cominak (Compagnie Minière d'Akouta), a consortium consisting of Cogema (34 percent), Onarem (Office Nationale des Resources Minières), the state-owned mineral resources company (31 percent), Japan's Overseas Uranium Resources Development Company (25 percent), and Enusa, the Spanish fuel-cycle company (10 percent). Cogema, the operator, currently takes about half of its output. The balance goes to Japanese and Spanish interests.

◆ The Arlit project is owned by Somair which, in turn, is owned by Onarem (33 percent), Cogema (27 percent), Compagnie Française Mokta, a subsidiary of Cogema (19.4 percent), Pechiney (7.6 percent), Italy's Agip Spa (6.5 percent), and Urangesellschaft (6.5 percent).

◆ The Arlit project is based on a series of open-pit mines. In 1988 production shifted from the three Arlit deposits to the nearby Taza deposit which offers somewhat higher grade ore and lower stripping ratios. Cogema, Onarem, and the Kuwait Foreign Trade and Construction Company own equal shares of the Taza deposit.

Political Developments

Uranium production in the Air region and its export to France are very important to the economy, and variations in the level of the French nuclear power program's annual purchases from Niger command the highest level of diplomatic interest. Uranium revenues were primarily responsible for Niger's historic prosperity in the late 1970s, but such revenues reached their zenith in 1979, and declined sharply after 1981, as uranium market conditions deteriorated. Even so, uranium revenues accounted for 80 percent of Niger's export earnings as recently as 1986.

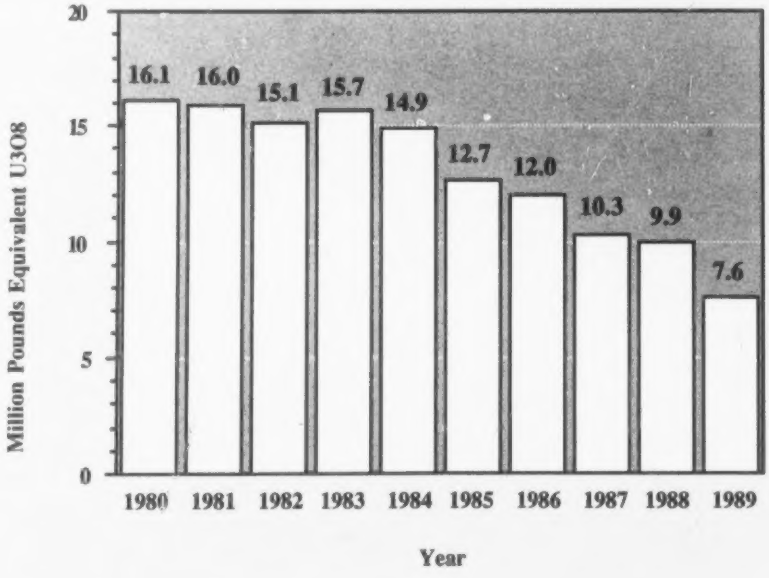
French purchases of Nigerien uranium began to increase in 1987, doubled during former President Kountché's terminal iliness, and have continued at a high level, largely to support his successor, Colonel Seibou. Without French foreign aid via uranium purchases, Niger's Zerma minority might well find its control of the government jeopardized. For example, the 1987-1991 Five-Year Plan counts on uranium exports to cover about one-eighth of the national budget.

SOUTH AFRICA

Uranium Production

By-product uranium output from the gold mines of South Africa has fallen precipitously over the past five years. Faced with anti-apartheid sanctions, increased costs associated with gold production, a significant drop in uranium prices, and domestic inflation, South Africa's uranium producers, which for over fifteen years produced one-sixth to one-seventh of the market, now account for only one-twelfth. For the first half of the 1980s, their output held steady at about 15 million pounds equivalent U_3O_8, but over the last five years, the total has declined by almost half (**Figure 8**). South Africa produced 7.6 million pounds equivalent U_3O_8 in 1989, a 23 percent decline from 1988.

Figure 8
SOUTH AFRICA URANIUM PRODUCTION
(1980-1989)



At the end of 1989, only seven uranium producers were operating (**Table 10**). The previous year, four uranium production centers shut down; Driefontein, Harmony, Randfontein, and Stilfontein (Chemwes). In 1988, they had accounted for over 1.8 million pounds equivalent U_3O_8, while in 1987, these four facilities had represented about 25 percent (2.5 million pounds) of South Africa's uranium production.

The major reason for the significant drop in South African production is the closure of the four facilities in 1988, but production at the mills operating in 1989 declined as well. The largest declines occurred in the first two quarters of the year, primarily due to significant production cuts at Vaal Reefs, the largest uranium producer in South Africa. Production levels fluctuated normally in the second and third quarters of the year, before the downward trend resumed late in the year. All facilities made production cuts in an effort to counter inflationary pressures such as wage hikes and declining gold prices.

Vaal Reefs, though its 1989 production fell five percent from 1988's level, still accounted for nearly half of all of South Africa's uranium production. Hartbeestfontein's 1989 production level declined, but remained relatively stable throughout the year. Hartbeestfontein produces uranium at a substantial loss, but is compensated for that loss by increased gold yields attributable to the removal of uranium before the gold recovery process. Western Areas finished the year with quarterly production levels well above any of its previous quarterly output levels of the past few years; this led to

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Table 10
SOUTH AFRICA URANIUM PRODUCTION BY MINE (1988-1989)

Mine	1988	1989	Percent Change[1]
Operating:			
Buffelsfontein	946	856	-9.5
ERGO[2]	393	382	-2.8
Freegold[3]	1,071	978	-8.7
Hartebeestfontein	813	759	-6.6
Vaal Reefs	4,158	3,935	-5.4
Western Areas	444	496	+11.7
Palabora	201	200	-0.5
Closed:			
Driefonstein	72	0	-100.0
Harmony	350	0	-100.0
Randfontein	486	0	-100.0
Stilfontein (Chemwes)	951	0	-100.0
Total	**9,885**	**7,606**	**-23.1**

[1] Change in percent from the 1988 total.
[2] ERGO=East Rand Gold and Uranium Company Ltd.
[3] Formerly Free State Joint Metallurgical Scheme.
[4] Columns may not add up due to rounding.

an increase of 52 thousand pounds equivalent U_3O_8 for 1989, the only increase in annual production reported by any South African uranium producer.

Anti-apartheid sanctions, primarily *de facto* rather than *de jure*, have made it very difficult for Nufcor (Nuclear Fuels Corporation of South Africa Pty., Limited), the firm responsible for marketing South African uranium, to extend long-term utility supply contracts or to sign any new ones. Declining uranium spot market prices have reduced revenues from that source, both in dollar and rand terms. In addition, since all South African uranium is recovered as a by-product of gold mining operations (except Palabora, which mines uranium as a by-product of copper), declining gold prices and rising production costs have also hampered uranium operations.

Until early 1988, South Africa's gold mines had been relatively insulated from the effects of the decline in dollar gold prices by the depreciation of the rand, which is valued against other currencies on a managed float by the South African Reserve Bank (SARB). Despite the effects of inflation on production costs, this maintained the mines' profitability, offsetting (in rand terms) about half of the dollar decline in uranium prices.

Because gold earns more foreign exchange than any other product, and is the largest source of private employment in the country, the devaluation was allowed to continue. But in 1989, the inflationary cost-price squeeze pushed several marginal gold mines to the brink of closure. In order to maintain profitable operations, albeit on a smaller scale, those mines laid off workers and reduced output to allow for the mining of higher average grades. Naturally, the effects of the gold cost/price squeeze carried over to some by-product uranium operations as well.

As a result of all of these factors, much of South Africa's uranium recovery capacity has been rendered uncompetitive. Some circuits have been shut down and dismantled; others have been converted to potentially more profitable gold recovery. To restore that capacity will require a price incentive substantially higher than that which would have allowed the continuation of production in the first place. Absent dramatic reversals in the political and economic factors affecting South Africa's uranium producers, further reductions in production levels, and at least one more uranium recovery circuit shutdown, will likely follow. For example, Freegold has announced plans to shut down the uranium recovery circuit at its Joint Metallurgical Scheme gold operation in the near term. South Africa's lost uranium recovery capacity will not be easily restored, once market conditions improve.

Nuclear Power Program

South Africa's only nuclear power station, Koeberg, improved its output for the second year in a row. The two-unit 1,840-MWe PWR station produced 11,730 gross MWh with an average capacity factor of 69 percent for 1989. This power production represents nearly a six-percent increase from 1988.

South Africa's semi-commercial scale helikon uranium enrichment plant at Valindaba, which came on stream during 1988, may soon be able to supply all of Koeberg's needs. And, of its 300 thousand SWU annual capacity, as much as one-third could be committed for export.

Although South Africa has not signed the NPT, locally produced fuel falls under IAEA full-scope safeguards as soon as it crosses the boundary of Koeberg. As a result of increasing pressure to sign the NPT, South Africa will probably do so in the next few years. Even though IAEA members have threatened to expel South Africa unless it does sign the NPT, a more encouraging note is that Eskom has been accepted into a new international body, the World Association of Nuclear Operators.

Political Developments

International political and economic pressures on South Africa continued to mount in 1989, as did domestic protest. The signing of the Angolan and Namibian peace agreements and the détente with Mozambique relieved South Africa's border security concerns, freeing the government to concentrate on resolving its internal problems. The limited sanctions against South Africa remained in force. Attempts at the Commonwealth conference in October to intensify sanctions were thwarted by the opposition of British Prime Minister Margaret Thatcher and by the post-election climate in South Africa. Full removal of sanctions is unlikely until after elections involving all South Africans.

Under P.W. Botha, the white minority government had already begun a very gradual process of empowering the country's black majority, but by 1989 the Botha government had become increasingly paralyzed. Botha, head of government since 1978, was replaced during August as state president by F.W. de Klerk, former minister of education and NP leader in the Transvaal.

September's parliamentary elections produced mixed results. Although the NP retained its majority in the (white) House of Assembly (93 to 73), thereby solidifying de Klerk's power, the party suffered its most serious loss of seats there since the 1950s, both to the right-wing Conservative Party (CP), and to the liberal Democratic Party (DP). Those two parties gained 17 and 12 seats respectively, so that the CP now holds 39 seats and the DP 33. Coloured and Indian voters effectively boycotted the elections for the other two houses, rendering those elections essentially meaningless. In protest against the exclusion of the black majority, the recently established Mass Democratic Movement (MDM) called a two-day general strike, in which three million participated on election day.

On a more positive note, however, the white election results showed that the shift of voters to the CP had abated. More than 70 percent of the votes were cast for other than CP candidates. The CP philosophy embodies the commitment to apartheid that, as recently as ten to fifteen years ago, represented the great majority of South African whites. The end of the white backlash against government liberalization, and the surprising gains by the DP, indicated that the electorate was ready for government initiatives and concessions to the disenfranchised black majority.

Under de Klerk's leadership the NP had campaigned on the basis of a five-year plan for ending apartheid and for the negotiation of a new constitution with representative leaders from all communities, including blacks. However, the plan rejected majority rule in favor of allowing minorities the right to control their "own affairs" and promising no "domination of minorities" by the majority. After the elections, President de Klerk, leading his party and country down the middle of the two extremes, made some long-expected reforms. He lifted the ban on anti-government protests, and eliminated the ban on all political associations, which effectively legalized the ANC. He also released a number of political prisoners in 1989, as a prelude to Nelson Mandela's February 1990 release. These actions, along with public statements by both sides that demonstrate their willingness to negotiate in good faith, have presented the opportunity for de Klerk to promote peace and a smooth transition to a multi-racial government, as well as an opportunity to encourage international acceptance of his country.

During 1990, negotiations between white and black leaders will dominate the South African political scene. The first step will be "talks about talks," as a preliminary to broader discussions. While Botha had imagined a threat of total onslaught by communist forces, de Klerk's government policies will link politics more closely to economics in an effort to avoid further sanctions and their debilitating economic impacts. ■

AUSTRALIA

Uranium Production

Australia's natural uranium concentrate output increased slightly in 1989 to 9.5 million pounds equivalent U_3O_8, (versus 9.3 million pounds in 1988), despite the fact that only Energy Resources of Australia's (ERA) Ranger mine in the Northern Territory and South Australia's Olympic Dam project operated during the year.

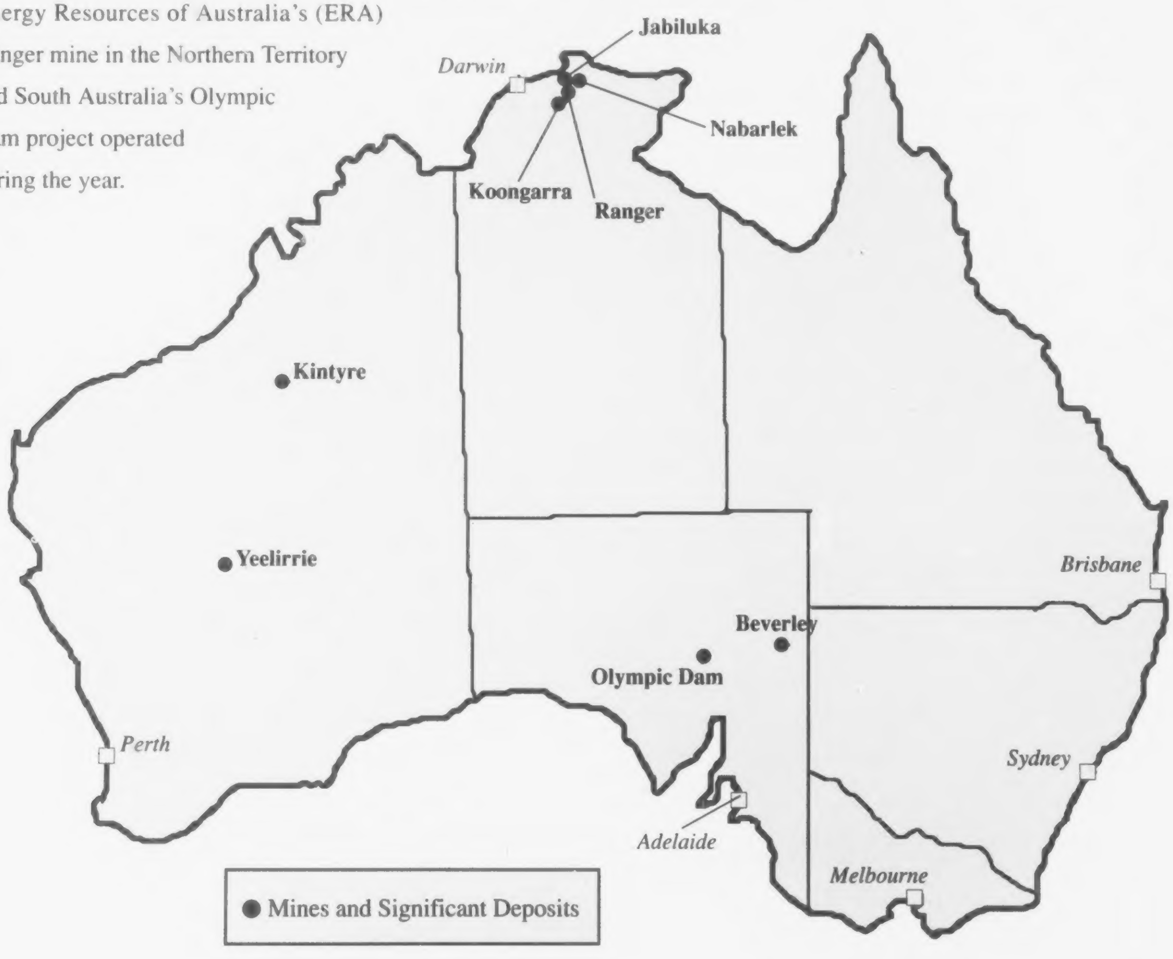
Jabiluka
Darwin
Nabarlek
Koongarra
Ranger
Kintyre
Yeelirrie
Brisbane
Beverley
Olympic Dam
Perth
Sydney
Adelaide
Melbourne
● Mines and Significant Deposits

Figure 9. Australian uranium mines and significant deposits.

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Queensland Mines

Having completed the milling of all its stockpiled ore during 1988, Queensland Mines Limited's (QML) principal activity during 1989 involved cleanup at the Nabarlek site and continued exploration on the surrounding lease area. At year end, QML, responding to press reports, indicated it was negotiating the sale, over the long term, of a portion of its uncommitted, six-million pound inventory. Separately, QML's parent, Pioneer International, announced its intention to dispose of all its mineral interests, including QML, although no buyer had been identified by year-end.

Olympic Dam

Due to the depressed state of the uranium market and high copper prices, the Western Mining-BP Australia Olympic Dam joint venture project focused on copper-rich ores during 1989, with the result that uranium production of 2.2 million pounds equivalent U_3O_8 fell nearly one million pounds short of planned levels. Several new long-term contracts, including the venture partners' first US sales, were concluded during the year, although some government approvals were still pending at year end. Finally, BP's proposed sale of its 49-percent interest in the project to RTZ, the UK-based mining giant, encountered unexpected legal obstacles, and, at year-end, its plans for disposing of that interest remained in limbo.

ERA

ERA produced almost 7.3 million pounds equivalent U_3O_8 in 1989, a slight increase over the 7.1 million pounds produced in 1988. ERA's main focus during 1989 involved the price renegotiations of its long-term contracts with its shareholder/customers. One West German shareholder, Rheinisch-Westfälisches Electrizitätswerk AG, decided to take no further deliveries after 1990; other ERA customers agreed to a \$26-per-pound U_3O_8 settlement price. The Australian government's approval signaled a long overdue recognition of market reality. Also reflecting the current situation, ERA officially deferred the long-planned Ranger expansion, pending an improvement of market conditions.

Other Developments

The Labor Government's Uranium Policy Review Committee, established in mid-1988, had been expected to recommend changes in Australia's uranium policy. But although the Committee held hearings and received written submissions during 1989, it had not made any recommendations by early 1990. Thus, the government's September announcement that it had approved the price settlements between ERA and its shareholder/customers came as something of a surprise. Though not formally stated, it is now clear that the government has abandoned its rigid floor price policy in favor of a more flexible approach that, in the words of the Minister of Primary Industries and Energy John Kerin, will reflect "the national interest in particular circumstances and the market conditions in which the contracts are negotiated."

The Review Committee's primary focus is apt to be the existing "three mine" policy and its possible revision. Despite today's bleak market conditions, a number of potential Australian producers are waiting in the wings, convinced that, given the unfilled demand in the longer term, there is a very real opportunity for a significant expansion of Australia's supplier role. Principal among them are CRA with its Kintyre find in Western Australia, and Pancontinental and Denison with, respectively, their Jabiluka and Koongarra deposits in the Northern Territory. However, the uncertainty surrounding this matter is unlikely to be resolved until after the March 1990 national elections. ■

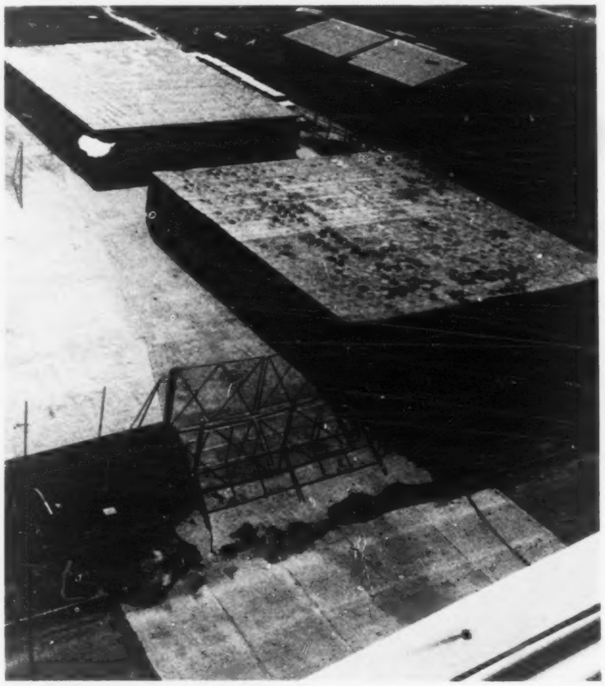

Figure 10. A portion of the U_3O_8 inventory stored at QML's Nabarlek stockpile. (*Photo courtesy of QML.*)

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EASTERN EUROPE

Since June 1989, the world has seen changes in Eastern Europe that would have seemed impossible just a year ago. The democratization of the East European countries has proceeded at an incredibly fast pace. And with it has come the opening of borders, the demolition of the "Iron Curtain," and the establishment of non-Communist governments. *Perestroika* and *glasnost* have increased the availability of information regarding the Soviet and other East European nuclear energy programs. The Soviet Union publicly acknowledged problems within its nuclear sector, and sought Western assistance (which also will aid nuclear programs of the East European countries, which use Soviet equipment and technology). The Soviet Union has also published information regarding its nuclear fuel supply industry for the first time. NUEXCO estimates that the Soviet Union and other East European states—Bulgaria, Czechoslovakia, East Germany, Hungary, and Romania—have produced as much as 40 million pounds equivalent U_3O_8 per annum. That figure is approximately equal to the US peak output of 44 million pounds in 1980.

Soviet Union
E. Ger.
Poland
Czechoslovakia
Hungary
Romania
Bulgaria

As part of the rapid opening of East European countries, the European Economic Community (EEC) signed an extensive trade agreement with the Soviet Union, and Techsnabexport (TENEX) of the Soviet Union expanded its marketing efforts. Czechoslovakia entered into an arrangement with a West German firm at year-end for assistance in exporting natural uranium concentrates to Western countries, and Hungary held extensive discussions with France on nuclear energy matters. These changes clearly indicate a greater role for Eastern Europe in the international nuclear fuel market of the 1990s.

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BULGARIA

As in all the East European countries, Bulgaria's nuclear power program is based upon Soviet technology. Presently, Bulgaria has five VVERs in operation (2,760 MWe), and three under construction (3,000 MW). Although two additional VVERs for 2,000 MWe are planned, their future is uncertain due to the weak economy. Nuclear power currently provides approximately 36 percent of Bulgaria's electricity. In 1988, Bulgaria signed technical cooperation agreements with West Germany for nuclear engineering services and with Asea Brown Boveri on High-Temperature Reactors (HTR). Bulgaria produces about two to three million pounds equivalent U_3O_8 per year, 70 percent of which is by in-situ leaching (ISL).

CZECHOSLOVAKIA

Czechoslovakia has eight VVERs in operation, for a total of 3,434 MWe. Eight additional VVERs are under construction (5,784 MWe) and six units are planned (6,084 MWe). Currently, nuclear power provides 27 percent of Czechoslovakia's electrical needs. Czechoslovakia's nuclear program calls for installed nuclear capacity to reach 10,300 MWe by the year 2000, surpassing coal-fired generation (currently the primary generator of electricity).

Most of the Czechoslovakian reactors are manufactured domestically by Skoda, and are based on the Soviet VVER design. Skoda recently won a contract to supply a nuclear plant to Bulgaria, and is giving more attention to safety features, such as the installation of seismic devices, sophisticated personal dosimetry equipment, and radiation protection measures.

Czechoslovakia has been mining and milling uranium for a considerable period of time for export to other East European countries, primarily the Soviet Union. As with the other East European countries that both produce uranium and operate nuclear power plants, uranium delivered to the Soviet Union has been returned in equal value as finished fuel assemblies.

Current production is about two to three million pounds equivalent U_3O_8 per year, but Czechoslovakia is escalating exploitation of uranium ore deposits in the northern part of the country. At the end of 1989, the state uranium mining company selected a West German agent to assist it with the export of approximately one million pounds equivalent U_3O_8 per year to Western countries.

EAST GERMANY

With the fall of the Berlin Wall in 1989, and efforts underway towards reunification with West Germany, East Germany has undergone tremendous change. In free elections held March 1990, the conservative parties aligned to West Germany won a majority of the seats. This indicates there will likely be a rapid unification of East and West Germany. East Germany has the most advanced industrial base in Eastern Europe, largely due to aid from West Germany. On the other hand, it has the third highest per capita energy consumption in the world, having relied on energy-intensive industries to fuel its growth. Like Japan, East Germany is poor in fossil energy resources and must import all of its fossil fuels; unlike Japan, East Germany has not embraced nuclear energy extensively.

East Germany has five VVERs in operation, for a total of 1,702 MWe. Two additional units totalling 816 MWe are under construction, while tentative plans call for adding 7,000 MWe of capacity by the year 2000. Cooperation between East and West Germany in the area of nuclear safety has begun to intensify.

East Germany has been the largest uranium producer in Eastern Europe, but actual production levels remain a closely-guarded secret. The state mining industry is reported to employ 40,000 people, and capacity could be as high as 15 million pounds equivalent U_3O_8 per year.

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HUNGARY

Hungary was the second East European country to embrace democracy and adopt major reforms, scheduling free elections for March 25, 1990. (Conservative parties, which favor rapid integration with Western Europe, won the elections). Hungary has been experimenting with a free market economy for several years, and is actively seeking Western participation in its economic reform efforts.

Hungary has four VVERs (total capacity of 1,760 MWe) in operation, producing almost 50% of the country's electrical energy. Plans for two additional VVER 1,000 units were suspended, yet plans to purchase a multi-unit station from a Western vendor were discussed in 1989. Construction of new units will be discussed after the March elections. The French nuclear industry is a leading contender to supply new nuclear power units to Hungary.

In September, Hungary became the first country in Eastern Europe to adopt the IAEA protocol for civil liability for nuclear accidents. An OSART (Operational Safety Review Team) team visited the Paks nuclear power station late in 1989 and gave the station high marks on operational safety and training. The Hungarian government is seeking to obtain new nuclear plants from Western vendors, to be financed by electricity sales.

In 1989, the Hungarian government announced it would soon close Hungary's only uranium mine, a deep shaft mine located at Pecs and operated by Mecsek Ore Mining Company (MEV), which had been in operation since 1956. Current output capacity is 1.0 to 1.5 million pounds equivalent U_3O_8 per annum, but falling world uranium prices and the high cost of mining at Pecs threaten its continued operation. Hungary's uranium deposits probably are sufficient to fuel 3,000 MWe for up to 40 years, but at costs well above current market prices.

POLAND

Poland was the leader in the process of East European democratization during 1989, having held free elections on June 4. Poland appears to have struck a stable political balance and has made progress in implementing economic reforms. The country faces severe problems, however, including US$39 billion in foreign debt, low productivity, and, until recently, an annual inflation rate of 600%.

Poland had two VVER 440 nuclear plants under construction at Zarnowiec (near Gdansk), and two additional units were planned for that site. However, construction was halted due to economic difficulties and public opposition to Soviet-design reactors. Consequently, Poland is actively pursuing the use of Western technology for the four units. Like other East European countries, Poland is seeking long-term financial arrangements from Western partners. In the interim, however, Poland's nuclear energy program is at a standstill. Poland is the only East European country without indigenous uranium production.

ROMANIA

In 1974, Romania had planned to have more than 20 reactors in operation within 15 years. To date, not a single reactor is in operation. Construction began in 1975 on two 600-MWe units at Cernavoda, and three more CANDU-type reactors are planned. The substantial delay in construction is due primarily to problems over payments still due to Canada. AECL (Atomic Energy of Canada Ltd.) has provided about 80% of the content of Unit 1, and somewhat less for Unit 2. Before President Ceausescu's fall, Romania had planned to build an additional 11 nuclear power stations, virtually eliminating consumption of fossil fuels for power generation. However, those plans have not been adopted by the new regime, and it is unlikely that any further announcements will be made until after the April elections. Romania has produced small quantities of uranium in the past. Capacity could be as much as 2.5 million pounds equivalent U_3O_8 per annum.

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SOVIET UNION

Without a doubt, Soviet President Mikhail Gorbachev's bold policies of *glasnost* (political openness) and *perestroika* (economic restructuring) dramatically changed the world during 1989. Business practices in the Soviet Union are changing at a brisk pace, and by its example, the Soviet Union has changed the orientation of all Eastern Europe towards the West.

To facilitate trade, the Soviet Union began limited currency reform in 1989, with the aim of making the ruble fully convertible by the year 2000. A broad free-trade pact was negotiated with the European Economic Community and signed early in 1990. In addition, the USA expressed its intent to give "most favored nation" trade status to the Soviet Union, in return for the removal of emigration restrictions. The Soviet Union also moved to join GATT (General Agreement on Tariffs and Trade), although that objective is not likely to be realized in the near future.

Nuclear Energy Program

The Soviet Union has 45 nuclear power units in operation totaling about 35,000 MWe. This includes 23 VVERs (PWR-type), 15 RBMKs (graphite-moderated Chernobyl-type), and 3 FBRs (Fast Breeder Reactors). In addition, the Soviet Union has a number of nuclear district heating plants in operation and under construction, all near large cities.

Nuclear energy provides about 13% of the total electrical production in the Soviet Union, about the same level as hydropower. In 1984, the Soviet Union projected that nuclear generation would reach 200,000 MWe by the year 2000; however, this goal was recently reduced to a range of 60,000 to 100,000 MWe. Widespread electricity shortages were anticipated during the winter of 1989-1990. These were due in part to the lack of capital investment in the power generation industry during 1989, and in part to delays in and shutdowns of various nuclear projects throughout the Soviet Union.

As freedom of expression increased, public pressures prompted the permanent shutdown or abandonment of construction on 35 nuclear and hydro plants, including Chernobyl 5 and 6; Smolensk 4; Kursk 6; Armenia 1 and 2; Ignalina 4 in Lithuania; Aktash 1 and 2; 1,000-MWe VVERs in Armenia, Azerbaijan, Georgia and the Caucasus; and a six-unit 1,000-MWe plant (Karhumaki) near the Finnish border. However, 18,960 MWe of VVERs remain under construction. The Soviet Council of Ministers also decided to cancel construction of all Chernobyl-type RBMK units, and to retrofit all 14 units built in the 1970s to meet current safety and quality assurance standards. The Soviet Union currently remains committed to the deployment of FBRs, and is developing both an 800-MWe and a 1,600-MWe reactor design.

Nuclear Fuel Exports

In keeping with *perestroika*, the Soviet nuclear power industry infrastructure was reorganized. The new Ministry for Atomic Energy and Industry (MAEI) combines the former State Committee for the Utilization of Atomic Energy, the former Ministry of Nuclear Power, and the former Ministry of Medium Machine Building. V/O Techsnabexport (TENEX) remains the marketing organization for nuclear fuel and fuel services under the new Ministry. TENEX is also responsible for the sale of fabricated fuel, including the contained enriched uranium, to the other East European countries. Such sales usually include the return of the spent fuel to the Soviet Union.

In late 1988, TENEX made a major policy change and began offering enriched uranium product (rather than just services) for sale on the world market. To aid its marketing efforts in the West, the Soviet Union established a stockpile of Soviet-enriched uranium in the USA at the fabrication facilities of GE and Westinghouse at the end of 1989.

One of the most interesting revelations from the Soviet Union came when, at the September 1989 Uranium Institute Conference, Mr. Alexander Chernov of TENEX discussed previously unreleased facts regarding the Soviet enrichment program and the underlying technology. While the Soviet Union initially built and operated gaseous diffusion plants (one of five may still be in operation), the backbone of its enrichment industry is the gas centrifuge, first put into commercial operation in the Soviet Union in 1959. This information countered the widely held Western belief that TENEX was selling the output from Soviet gas diffusion plants; it explains in large part the ability of TENEX to offer competitive prices on the world nuclear fuel market.

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Other Developments

As part of the new Soviet openness, the Soviet Union hosted the founding meeting of the World Association of Nuclear Operators (WANO) early in 1989. Further, the Soviet Union and Canada entered into an Agreement for Nuclear Cooperation, which allows for the transfer of patents and other proprietary rights; for the application of nuclear technology to agriculture, industry, medicine and power generation; for industrial cooperation; for technical assistance; and for cooperation in uranium exploration and development. (This agreement, however, does not address the question of return of tails material for Canadian-origin uranium enriched in the Soviet Union.) The Soviet Union has also signed agreements with the West for upgrading the safety systems and monitoring equipment for Soviet VVER (PWR-type) class reactors.

On other fuel cycle activities, the Soviet Union has proposed the establishment of an International Atomic Energy Agency (IAEA) research center to be located at Chernobyl, to study the various post-accident problems raised by the Chernobyl accident in 1986. The Soviet Union has also offered to host a high-level waste disposal project.

Uranium Production

Uranium in the Soviet Union is largely recovered through by-product or co-product mining operations, or by in-situ leaching (ISL). Uranium is recovered from phosphates; lignite; and precious, base, and specialty metals. For example, **Figure 11** shows a lignite mine at the MeLovoe deposit on the Mangyshlak Peninsula, Kazakhstan.

At present, ISL accounts for about 20 percent of uranium concentrate production, but is expected to account for up to 45 percent in coming years, due to cost effectiveness and technological improvements. In the Soviet Union, the low overhead and economies of scale resulting from large, efficient mining operations operated by one company tend to keep production costs low, relative to other countries. The recovery of a number of by-products enhances the value extracted from many deposits.

Identified reserves of uranium in the Soviet Union are ample for Soviet nuclear energy requirements for more than 100 years (at average rates of development of nuclear energy and if reprocessing is continued). ■

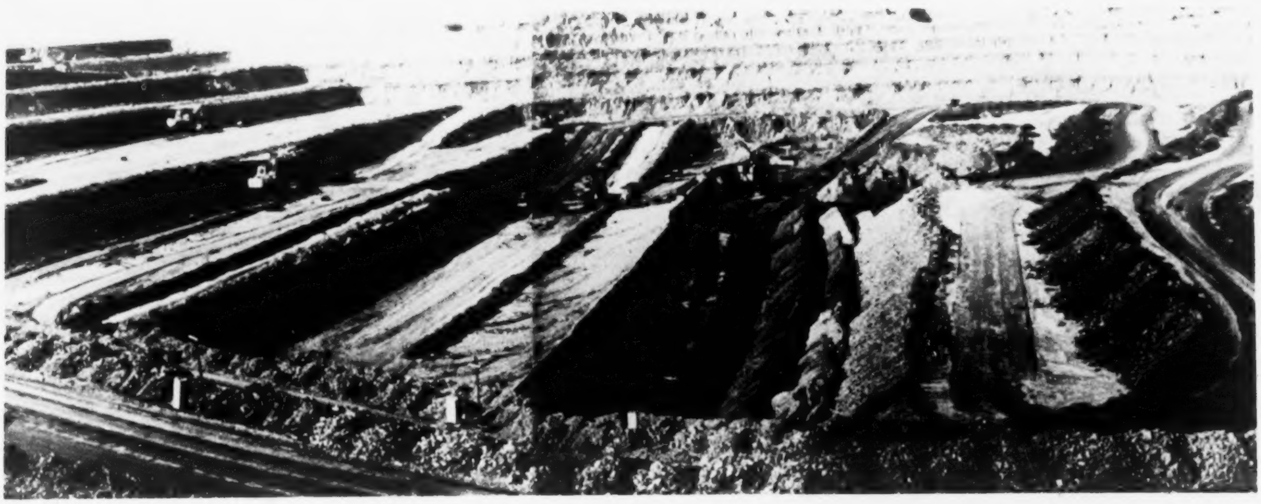

Figure 11. The MeLovoe lignite mine on the shore of the Caspian Sea. The lignite is burned in a nearby power station and the ash is leached to recover uranium. *(Photo courtesy of TENEX.)*

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WESTERN EUROPE

Nuclear electricity generated in Western Europe rose to 735,000 GWh in 1989 (**Table 11**), an increase of 5.5 percent over the 1988 figure of 696,000 GWh, and a further sign of the importance of nuclear energy to the West European economy. An exceptionally warm climate during the year led to low hydro utilization in some countries, to cooling problems at some nuclear stations, and to reduced electricity demand for heating during the winter months. The warm climate contributed to widespread concern throughout Europe about the greenhouse effect resulting from thermal power generation. Furthermore, the rapid opening of East European countries during the course of 1989 alerted West Europeans to the severe environmental problems caused by outdated thermal plants in those countries. Developments in Eastern Europe also highlighted the enormous potential power demand in that region as countries there adopt Western economic policies.

Despite the positive developments for the long-term future of nuclear energy, no new plant orders were placed. Furthermore, the United Kingdom (UK), which had inaugurated an ambitious PWR construction program for the 1990s, drastically curtailed that program late in 1989. Only nine reactors remain under construction in Western Europe—Sizewell B in the UK, and eight large units in France. Further nuclear power development might not occur until the second half of the 1990s, when advanced or inherently, passively safe reactor programs may be commercialized, probably in the USA before in Europe.

Finland
Sweden
The Netherlands
Belgium
UK
West Germany
Austria
France
Switzerland
Italy
Yugoslavia
Portugal
Spain

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AUSTRIA

Gemeinschaftskraftwerk Tullnerfeld GmbH (GKT), owner of the cancelled Tullnerfeld nuclear project, moved to liquidate all remaining nuclear assets in 1989 and neared a formal decision to convert the plant to a gas-fired station. Austria's sole nuclear power plant, a 720-MWe BWR, was ordered from Kraftwerk Union in 1971. Design and construction proceeded without undue technical or construction problems, but the plant met with public and political opposition from the beginning. In November 1979, when Tullnerfeld was about 98-percent complete, its opponents initiated a public referendum to decide whether the plant should be operated. The anti-nuclear faction won by a narrow margin, and the project was halted.

For the next six years, the plant was maintained in a standby condition while successive governments in Austria debated whether to reverse the anti-nuclear policy. By the end of 1985, it appeared that proponents might be able to develop sufficient political support to propose a new referendum to allow operation of the plant. However, political repercussions of the Chernobyl accident in early 1986 effectively eliminated the nuclear option.

Preliminary results of studies to determine the economic viability of converting Tullnerfeld to a gas-fired station seem favorable, and a final decision will probably be made during 1990. In the meantime, GKT has sold certain plant components that will not be needed if the plant is converted to a gas-fired station, as well as enriched uranium recovered from defabrication of the plant's first core. The fuel, which is being converted from enriched uranium oxide to enriched UF_6 by Comurhex in France, was sold by GKT during the first quarter of 1990.

Table 11
1989 NUCLEAR POWER GENERATION IN WESTERN EUROPE

Country	Number of Units (end of 1989)	1988 Nuclear Generation (GWh Gross)[1]	1989 Nuclear Generation (GWh Gross)[1]	1989 Relative To 1988
Belgium	7	43,101	41,162	- 4.5%
Finland	4	19,276	18,798	- 2.5%
France	55[2]	274,862	301,722	+ 9.8%
Netherlands	2	3,675	4,019	+ 9.4%
Spain	10	50,430	56,118	+ 11.3%
Sweden	12	69,405	65,600	- 5.5%
Switzerland	5	22,689	22,754	+ 0.2%
United Kingdom	40	63,473	71,276	+ 12.3%
West Germany	21[3]	145,215	149,053	+ 2.6%
Yugoslavia	1	4,135	4,147	+ 0.3%
Total	**157**	**696,261**	**734,649**	**+ 5.5%**

[1] Source: *Nucleonics Week*

[2] Includes Superphénix, shut down for the latter part of 1989 for licensing reasons.

[3] Includes THTR-300

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BELGIUM

Belgium's seven nuclear units operated at an average capacity factor of 82 percent in 1989 (**Table 12**), and provided 61 percent of the country's electricity. Four of the seven units are located at Doel in northern Belgium, and three are located at Tihange in the southern part of the country. The three principal Belgian utilities—EBES, UNERG, and INTERCOM—share ownership in all seven units, and Electricité de France (EdF) holds a share of the Tihange units. In early 1990, the three private utilities announced plans to merge in order to improve their competitive position for the 1990s.

In 1989, the private utilities and the government entity SPE (Société Publique Cooperative d'Electricité) reached a restructuring agreement, under which SPE will assume one-third of the three companies' combined 25-percent share of the two 1,400-MWe PWRs under construction at Chooz in France, near the Belgian border. In addition, SPE will participate in Synatom, the fuel supply company responsible for all uranium procurement.

Synatom continued its policy of supply diversification during 1989, while encouraging unconventional sources, as some of its older long-term contracts expired. The company negotiated a new enrichment contract with Eurodif for 1991-95. Synatom is a shareholder in Eurodif, from which it buys about two-thirds of its enrichment needs.

Table 12
NUCLEAR POWER UNITS IN BELGIUM

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Doel 1	Synatom	392	PWR	1975	73	2,640
Doel 2	Synatom	392	PWR	1975	72	2,610
Doel 3	Synatom	900	PWR	1982	74	6,087
Doel 4	Synatom	980	PWR	1985	86	7,884
Tihange 1	Synatom	870	PWR	1975	85	6,872
Tihange 2	Synatom	900	PWR	1983	84	6,936
Tihange 3	Synatom	980	PWR	1985	89	8,133
Total MWe in Operation		**5,414**		***(1989 Average:***	**82)**[3]	**41,162**

[1] COD = Commercial Operation Date
[2] Source: *Nucleonics Week*
[3] Average does not include those units which entered commercial operation or were retired during 1989.

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FINLAND

Finland's four nuclear units achieved an average capacity factor of 89 percent in 1989 (**Table 13**). Prime Minister Harri Holkeri supports construction of a fifth nuclear unit to satisfy the country's future demands for electricity, which may exceed supply within five years. However, although public opinion polls indicate increasing support for nuclear power, formal government approval of the next nuclear unit to be ordered is not expected until after Finland's 1991 general election.

During 1989, Teollisuuden Voima Oy (TVO), the owner of two 710-MWe BWRs at Olkiluoto, excavated the cavern for its underground repository for low and medium-level wastes. The depository, located 60-90 meters below sea level at Olkiluoto, will contain all of TVO's low and medium-level active wastes for 40 years. Construction is scheduled to be completed by 1992.

Imatran Voima Oy (IVO), which operates two USSR-supplied 440-MWe PWRs near Loviisa, purchases all of its fuel, including the contained enriched uranium, from the Soviet Union, so it does not purchase uranium from Western companies. The Soviet Union also takes back the spent fuel as part of the supply package.

TVO received its natural uranium supplies under long-term contracts with Canadian and Chinese producers. It also purchased some quantities on the spot market.

Table 13
NUCLEAR POWER UNITS IN FINLAND

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Loviisa 1	IVO[3]	445	PWR	1977	92	3,765
Loviisa 2	IVO	445	PWR	1981	92	3,734
Olkiluoto 1	TVO[4]	710	BWR	1979	82	5,250
Olkiluoto 2	TVO	710	BWR	1982	94	6,049
Total		**2,310**		***(1989 Average:***	**89)[5]**	**18,798**

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] IVO = Imatran Voima Oy

[4] TVO = Teollisuuden Voima Oy

[5] Average does not include those units which entered commercial operation or were retired during 1989.

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FRANCE

France's national utility, Electricité de France (EdF), brought one new reactor on line during 1989, Nogent-sur-Seine 2 (1,310-MWe PWR) (**Figure 12**), bringing to 55 the number of commercial power reactors in operation in France (**Table 14**). Work continued on the remaining eight units in the French nuclear construction program, three of which (Penly 1, Cattenom 3, and Golfech 1) are scheduled for connection to the grid in 1990. EdF placed no reactor order in 1989.

In January, following a 19-month shutdown due to coolant problems, the Superphénix fast breeder reactor at Creys-Malville, owned by a European consortium, was licensed for eight months of further operation. In June, the Société d'Energie Nucléaire Franco-Belge des Ardennes (SENA) announced plans to retire Chooz A (305-MWe PWR) in mid-1991, just prior to the expected start-up of Chooz-B1 (1,440-MWe PWR).

France's 55 operational reactors achieved an average 64-percent capacity factor in 1989, producing over 300,000 GWh, nearly 80 percent of the country's total electricity production. France also continued to export electricity, sending a net 42,200 GWh to neighboring countries in 1989 (**Table 15**).

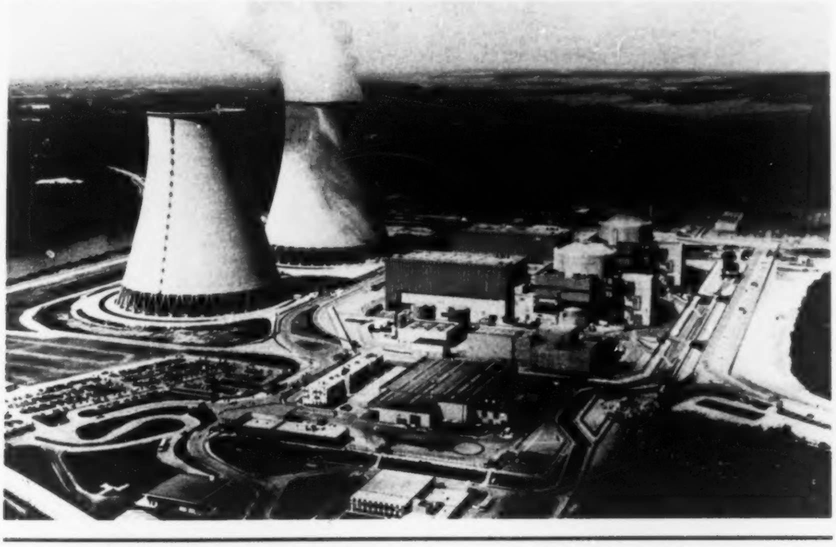

Figure 12. Nogent-sur-Seine nuclear station (two 1,310-MWe PWRs). *(Photo courtesy of EdF.)*

Political and Regulatory Developments

France signed several nuclear cooperation agreements in 1989:

◆ At the end of January, the French and Soviet governments signed an agreement to cooperate in all sectors of peaceful nuclear energy development.

◆ On February 16, France, West Germany, and the United Kingdom (UK) signed an agreement to further the development of the European Fast Reactor (EFR).

◆ In June, France and West Germany signed a cooperation agreement covering most aspects of the nuclear industry, including commercial reactor development and long-term spent fuel reprocessing.

◆ In September, Framatome, the French reactor vendor, announced an agreement to cooperate with Babcock and Wilcox (B&W) of the USA to market LWRs and related services in the USA.

◆ In October, EdF and Tokyo Electric Power Company (TEPCO) signed an agreement to cooperate in nuclear plant safety, operation, environmental protection, and information exchange.

During 1989, France also advocated EEC cooperation in all industrial sectors, including nuclear energy.

The French government reviewed the Commisariat à l'Energie Atomique's (CEA) role as coordinator of the French nuclear industry in 1989. The CEA is evaluating medium- and long-term nuclear research plans in order to select technologies for enrichment, reprocessing, and a new generation of reactors. The CEA is also expected to restructure the fuel supply industry in order for it to better adapt to the current market. Cogema is a wholly-owned subsidiary of the CEA.

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Table 14
NUCLEAR POWER UNITS IN FRANCE

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Belleville 1	EdF[3]	1,310	PWR	1988	46	5,380
Belleville 2	EdF	1,310	PWR	1988	76	8,907
Blayais 1	EdF	910	PWR	1981	78	6,535
Blayais 2	EdF	910	PWR	1983	70	5,850
Blayais 3	EdF	910	PWR	1983	76	6,393
Blayais 4	EdF	910	PWR	1983	73	6,131
Bugey 1	EdF	540	GCR	1972	38	1,850
Bugey 2	EdF	920	PWR	1979	59	4,912
Bugey 3	EdF	920	PWR	1979	62	5,189
Bugey 4	EdF	900	PWR	1979	71	5,859
Bugey 5	EdF	900	PWR	1980	61	5,034
Cattenom 1	EdF	1,300	PWR	1987	61	7,198
Cattenom 2	EdF	1,300	PWR	1988	16	1,872
Chinon A3	EdF	360	GCR	1967	31	1,378
Chinon B1	EdF	870	PWR	1984	62	5,012
Chinon B2	EdF	870	PWR	1984	79	6,424
Chinon B3	EdF	905	PWR	1987	66	5,338
Chinon B4	EdF	905	PWR	1988	61	4,967
Chooz A	SENA[4]	305	PWR	1967	61	1,729
Cruas 1	EdF	880	PWR	1984	73	5,936
Cruas 2	EdF	915	PWR	1985	80	6,593
Cruas 3	EdF	880	PWR	1984	72	5,830
Cruas 4	EdF	880	PWR	1985	63	5,121
Dampierre 1	EdF	890	PWR	1980	83	6,847
Dampierre 2	EdF	890	PWR	1981	70	5,793
Dampierre 3	EdF	890	PWR	1981	76	6,246
Dampierre 4	EdF	890	PWR	1981	69	5,698
Fessenheim 1	EdF	880	PWR	1977	42	3,387
Fessenheim 2	EdF	880	PWR	1978	72	5,891
Flamanville 1	EdF	1,300	PWR	1986	78	9,139
Flamanville 2	EdF	1,300	PWR	1987	43	5,041
Gravelines B1	EdF	910	PWR	1980	64	5,351
Gravelines B2	EdF	910	PWR	1980	80	6,716
Gravelines B3	EdF	910	PWR	1981	79	6,600
Gravelines B4	EdF	910	PWR	1981	62	5,233
Gravelines C5	EdF	910	PWR	1985	75	6,323
Gravelines C6	EdF	910	PWR	1985	65	5,444

(continued on next page)

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[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] EdF = Electricité de France

[4] Chooz Unit A is owned and operated by SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes), owned 50-percent each by EdF and the Belgian utilities.

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Table 14
NUCLEAR POWER UNITS IN FRANCE
(continued)

Units In Operation *(continued)*

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Nogent sur Seine 1	EdF[3]	1,310	PWR	1988	28	3,313
Nogent sur Seine 2	EdF	1,310	PWR	1989	65	7,519
Paluel 1	EdF	1,330	PWR	1985	70	8,255
Paluel 2	EdF	1,330	PWR	1985	79	9,357
Paluel 3	EdF	1,330	PWR	1986	72	8,463
Paluel 4	EdF	1,330	PWR	1986	73	8,599
Phénix	CEA[4]	233	LMFBR	1973	30	655
St Alban 1	EdF	1,355	PWR	1986	60	7,109
St Alban 2	EdF	1,355	PWR	1987	54	6,386
St. Laurent A1	EdF	390	GCR	1969	35	1,519
St. Laurent A2	EdF	450	GCR	1971	30	1,401
St. Laurent B1	EdF	915	PWR	1983	86	6,969
St. Laurent B2	EdF	880	PWR	1983	66	5,365
Superphénix	NERSA[5]	1,200	LMFBR	1986		
Tricastin 1	EdF	915	PWR	1980	73	6,119
Tricastin 2	EdF	915	PWR	1980	65	5,423
Tricastin 3	EdF	915	PWR	1981	73	6,113
Tricastin 4	EdF	915	PWR	1981	72	6,010
Total		**52,568**		*(1989 Average:*	**64)**[6]	**301,722**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[7]
Cattenom 3	EdF	1,300	PWR	1990	94
Cattenom 4	EdF	1,300	PWR	1991	81
Chooz B1	EdF	1,455	PWR	1992	70
Chooz B2	EdF	1,455	PWR	1993	51
Golfech 1	EdF	1,310	PWR	1990	93
Golfech 2	EdF	1,310	PWR	1993	60
Penly 1	EdF	1,310	PWR	1990	94
Penly 2	EdF	1,310	PWR	1992	70
Total		**10,750**			

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[1] COD = Commercial Operation Date (actual or expected)

[2] Source: *Nucleonics Week*

[3] EdF = Electricité de France

[4] CEA = Commisariat à l'Energie Atomique

[5] Superphénix is owned by NERSA, a European consortium of which the shareholders are EdF (51%), ENEL (33%), and SBK (16%). SBK is owned by RWE (West Germany, 68.75%), SEP (The Netherlands, 14.75%), Electronucléaire (Belgium, 16.5%) and CEGB (UK, 1.75%).

[6] Average does not include those units which entered commercial operation or were retired during 1989.

[7] Source: *Nuclear News*

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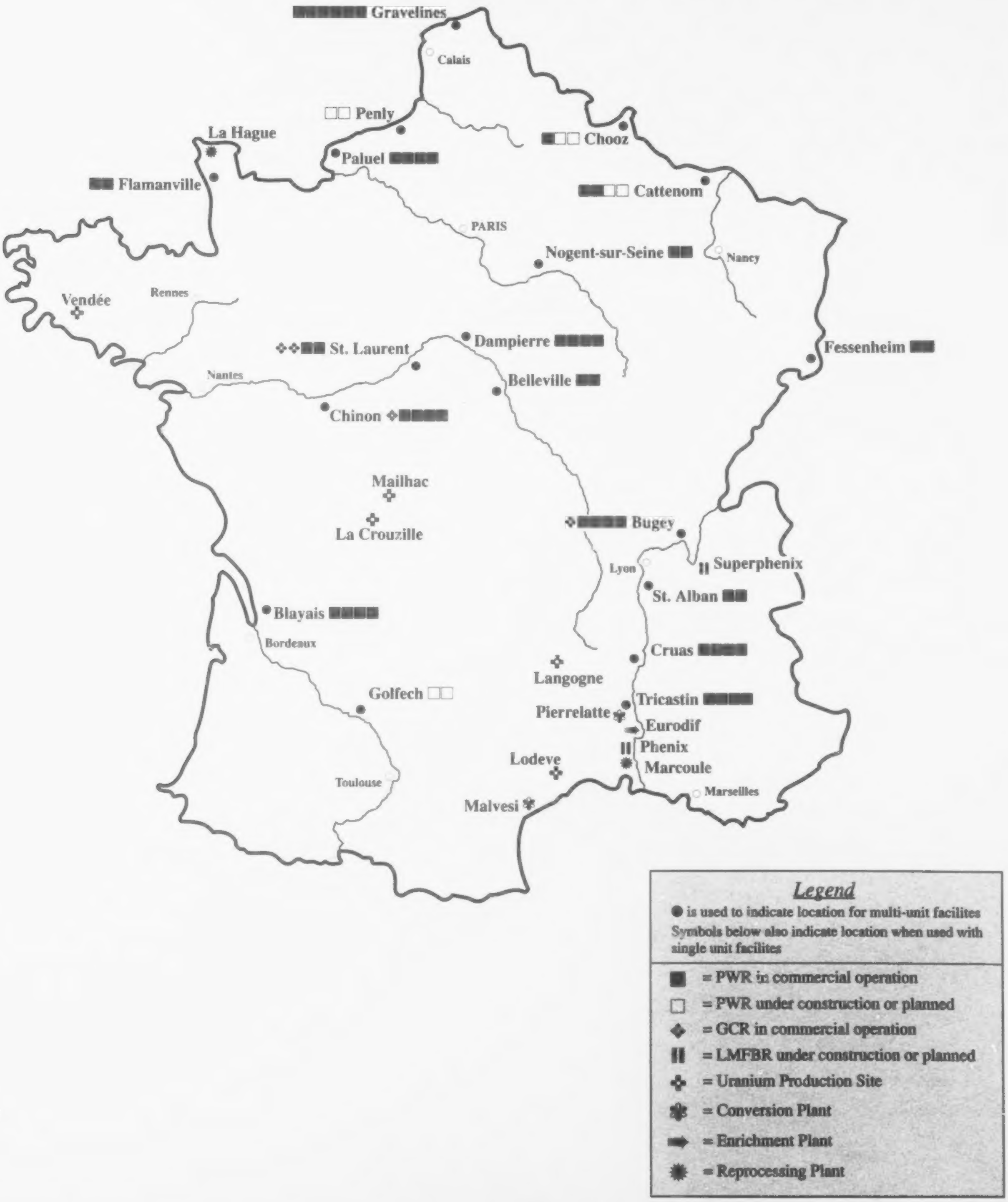
Figure 13
FRANCE
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES


■■■■■■ Gravelines
Calais
□□ Penly
La Hague
Paluel ■■■■
■□□ Chooz
■■ Flamanville
■■□□ Cattenom
PARIS
Nogent-sur-Seine ■■
Nancy
Vendée
Rennes
◆◆■■ St. Laurent
Dampierre ■■■■
Fessenheim ■■
Nantes
Belleville ■■
Chinon ◆■■■■
Mailhac
La Crouzille
◆■■■■ Bugey
Superphenix
Lyon
St. Alban ■■
Blayais ■■■■
Bordeaux
Cruas ■■■■
Langogne
Golfech □□
Tricastin ■■■■
Pierrelatte
Eurodif
Phenix
Lodeve
Marcoule
Toulouse
Marseilles
Malvesi
Legend
● is used to indicate location for multi-unit facilites
Symbols below also indicate location when used with single unit facilites
■ = PWR in commercial operation
□ = PWR under construction or planned
◆ = GCR in commercial operation
‖ = LMFBR under construction or planned
✣ = Uranium Production Site
✽ = Conversion Plant
➡ = Enrichment Plant
✹ = Reprocessing Plant

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Nuclear Fuel Supply and Procurement

Cogema and Total Compagnie Minière (TOTAL) are France's leading uranium supply companies. Cogema produced 7.0 million pounds equivalent U_3O_8 domestically in 1989 and maintained extensive mining interests in Africa, Australia, Canada, and the USA. However, at the end of 1989, Cogema announced plans to close its Vendée mining division and its Morvan mines in its La Crouzille Division, and delay development of the Guern-er-Vilin deposit at Berne due to poor market conditions.

TOTAL produced 1.4 million pounds equivalent U_3O_8 in France, and other material through its US subsidiary. TOTAL also owns ten percent of Rössing Uranium Ltd. in Namibia. Almost all natural uranium concentrates produced in France, as well as material from the African mines, are used by the French nuclear industry.

EdF, with natural uranium requirements of about 20 million pounds equivalent U_3O_8 per year, depends on Cogema for about 75 percent of its supplies and on TOTAL for about 10 percent. The balance of its purchases during 1989 came under long-term contracts with ERA in Australia, CNEIC in China, ENU in Portugal, and Malapai Resources in the USA. In addition to supplies under contract, EdF has a large inventory of natural uranium stored in France. The utility does not foresee further contracting activity until after 1995, although it has indicated an interest to invest in a US mining project.

Comurhex, the French UF_6 conversion company controlled by Pechiney, performs most of the conversion services for EdF as well as a number of utilities in Western Europe and Japan. Comurhex also operates a commercial reconversion circuit used to transform enriched uranium oxide into UF_6. The process has been used by some utilities to dispose of fabricated fuel by first converting the pellets to UF_6, which is a more fungible commodity.

During 1989, EdF completed the negotiation of its Eurodif enrichment contract for SWU deliveries in 1991-95. The contract is held via Cogema, the largest shareholder in the multinational Eurodif consortium. As part of the negotiation, EdF deferred substantial enrichment withdrawals into the 1990s, eliminating some excess enriched uranium inventory. EdF also receives enriched uranium from the Soviet Union via Cogema.

EdF continued to recycle spent fuel under contracts with Cogema and its affiliates. In 1989, the use of reprocessed UF_6 as feed material and plutonium in fabricated fuel satisfied 5 to 10 percent of EdF's fuel requirements. France's new reprocessing facility (UP3), and the new plutonium mixed-oxide (MOX) fuel assembly plant (MELOX), are scheduled for service in 1992-94. The new facilities will enable EdF to further increase the use of recycled material in its long-term supply mix.

Table 15
FRENCH ELECTRICITY IMPORT/EXPORT NET BALANCE[1]
1987-1989 (TWh)

	1987			1988			1989		
	Shared[2]	**Other[3]**	**Total**	**Shared[2]**	**Other[3]**	**Total**	**Shared[2]**	**Other[3]**	**Total**
Belgium/The Netherlands	- 1.4	2.9	1.5	- 0.8	3.9	3.1	- 1.3	4.9	3.6
Italy	0.3	4.8	5.1	0	9.6	9.6	0.6	10.8	11.4
Monaco	0	0.2	0.2	0	0.3	0.3	0	0.3	0.3
Spain/Portugal	- 0.8	2.3	1.5	- 0.8	2.0	1.2	- 0.6	0.1	- 0.5
Switzerland	3.2	3.8	7.0	3.7	3.3	7.0	4.0	8.7	12.7
United Kingdom	0	12.0	12.0	0	13.0	13.0	0	13.0	13.0
West Germany	2.6	0	2.6	2.7	0	2.7	2.3	- 0.6	1.7
Total	**3.9**	**26.0**	**29.9**	**4.8**	**32.1**	**36.9**	**5.0**	**37.2**	**42.2**

[1] *Source*: EdF

[2] Balance from cross-participation in power plants. (For example, France had a net import from Belgium and The Netherlands because of EdF's part ownership in Belgium's Tihange plant.)

[3] Other means straight sales, purchases, or exchanges of electricity.

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ITALY

Following a 1987 referendum prohibiting new nuclear plant construction until 1992, the government halted the operation and construction of Italy's nuclear plants. Latina (153-MWe GCR), which had been operating for 23 years, was shut down permanently. Trino 1 (260-MWe PWR) and Caorso (860-MWe BWR) were closed indefinitely, and construction was halted on Trino 2 (952-MWe PWR) and the two-unit station at Montalto di Castro. The government later approved Montalto's conversion to a gas and coal station. Thus, Italy, which once was one of the pioneer countries in commercial nuclear power development, now is only moderately active in advanced reactor cooperative development work.

Italy's current energy plan, which the government announced in September 1989, does not call for nuclear energy in the near future, although it does continue R&D funding for inherently, passively safe nuclear reactors. ENEL (Ente Nazionale per l'Energia Elettrica), the national utility, currently participates in three reactor development projects—the AP-600 and the SBWR under the DOE and Electric Power Research Institute program, and ABB Atom's PIUS (Process Inherent Ultimate Safety) program. Italy withdrew from the Superphénix fast breeder reactor project in 1989, but Ansaldo and ENEA (Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e dell'Energia Alternativa) still participate in design and key component development of PRISM (Power Reactor Inherently Safe Module), the GE modular breeder concept funded by DOE.

The retrenchment in nuclear energy, the difficulty in gaining approval to build conventional units, and an annual growth rate in electricity demand of over four percent, have increased Italy's reliance on imported electrical energy. Italy buys substantial amounts of electricity from France and other neighboring countries. Under a recent agreement, the Soviet Union will supply Italy with electricity in exchange for Italy's assistance in modernization and construction of Soviet power plants. ENEA and Agip Spa still own a cumulative 16.25 percent in the Eurodif enrichment consortium.

THE NETHERLANDS

The Netherlands' two operating nuclear units, the 470-MWe Borssele PWR and the 60-MWe Dodewaard BWR, achieved gross capacity factors of 86 and 74 percent, respectively, in 1989.

The Netherlands deferred decision-making on new nuclear plant construction following the Chernobyl accident. Although a new bipartisan government composed of Christian Democrats and Social Democrats was elected in 1989, the platforms of both parties do not envision nuclear plant construction for at least four more years.

PZEM (NV Provinciale Zeeuwse Electriciteits Maatschappij), owner of Borssele, bought all of its natural uranium requirements on the spot market in 1989. Its enrichment needs are covered by a requirements contract with Urenco, which operates an enrichment plant in The Netherlands.

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PORTUGAL

Portugal has no domestic nuclear power program at present, and has not yet determined if it will utilize nuclear power for a portion of its electricity needs in the future. In 1989, Electricidade de Portugal (EdP) signed a contract with Electricité de France (EdF) to import a guaranteed capacity of 312 MW per year for up to ten years, beginning in 1994. Portugal had been concerned about Spain's cooperation in transporting the electricity at reasonable prices, and about the long-term affordability of French electricity imports, but those concerns have been relieved by a recently signed trilateral agreement.

The sole uranium mine of Empresa Nacional de Uranio (ENU) located at Urgeirica, produced about 400 thousand pounds equivalent U_3O_8 in 1989, the same as in recent years. Most of this production is sold to EdF under long-term contract.

SPAIN

Spain had ten nuclear power units in operation during 1989, and two units, Valdecaballeros 1 and 2, under indefinite construction suspension. The ten operating units produced a record 56,000 GWh of electricity at an average capacity factor of 82 percent (**Table 16**).

In October 1989, an oil-based fire in the turbine hall of the 500-MWe Vandellos 1 GCR caused widespread damage to the plant, located south of Barcelona. Although no personnel were seriously injured, no radiation escaped, and no nuclear portions of the unit were damaged, the fire attracted international attention and provoked demonstrations in Spain. The unit is owned by a Spanish/French consortium, HIFRENSA. While no decision has been made on the unit's future, it is likely to be shut down permanently after nearly twenty years of service.

Hydropower generation in 1989 fell 45 percent below normal, as Spain suffered its driest year since 1962. Consequently, nuclear power generation reached a new high, contributing 38 percent of Spain's total electricity, an 11-percent increase over 1988's record level.

Electricity consumption increased 5.4 percent during 1989. If this pace continues, Spain will need additional electrical generating capacity by 1995, part of which could be supplied by the mothballed Valdecaballeros nuclear station (2,000 MWe). A new government energy plan is expected within the next two years, and with it a revival of the nuclear building program is likely.

Figure 14. Almaraz 1 and 2 (900-MWe PWRs). *(Photo courtesy of ENUSA.)*

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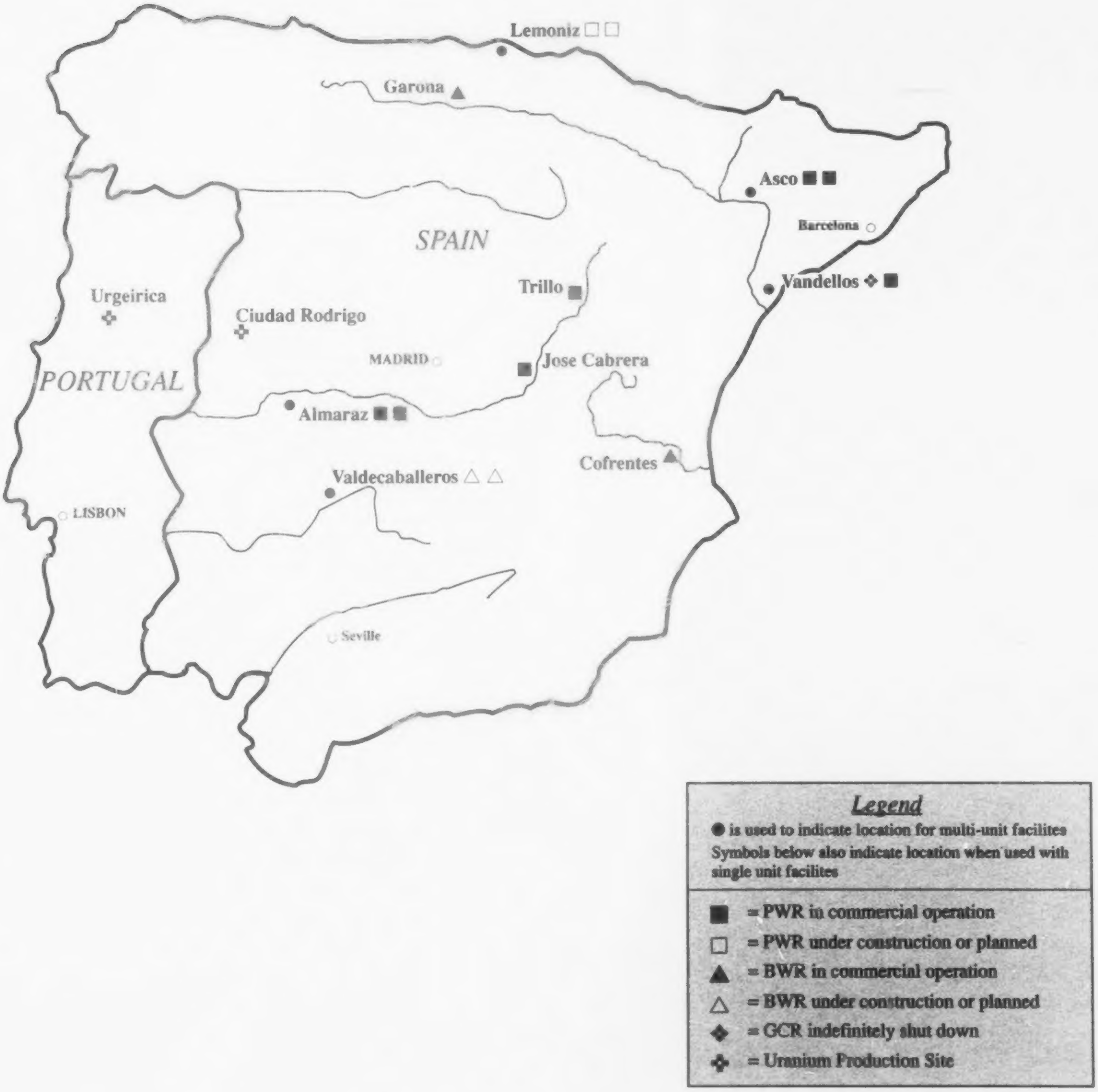
Figure 15
SPAIN AND PORTUGAL
NUCLEAR POWER UNITS AND URANIUM PRODUCTION AREAS


Lemoniz □ □
Garona ▲
Asco ■ ■
Barcelona
SPAIN
Trillo ■
Vandellos ◆ ■
Urgeirica
Ciudad Rodrigo
MADRID
Jose Cabrera ■
PORTUGAL
Almaraz ■ ■
Cofrentes ▲
Valdecaballeros △ △
LISBON
Seville

Legend

● is used to indicate location for multi-unit facilites
Symbols below also indicate location when used with single unit facilites

■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
◆ = GCR indefinitely shut down
✚ = Uranium Production Site

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Prompted by growing electricity demand, the government announced a $167-million agreement among Spain, France, and Portugal to construct a high-voltage transmission line across the Pyrenees. The government is also considering restructuring the electricity industry to promote greater efficiency and reduce costs.

Uranium exploration continued in 1989 in the provinces of Salamanca and Ceaceres. At year-end, ENUSA (Empresa Nacional del Uranio SA), the state-owned nuclear fuel company and fuel fabricator, appeared close to a decision to increase domestic uranium production at Ciudad Rodrigo from approximately 500 thousand pounds equivalent U_3O_8 in 1989 to as much as 2.5 million pounds beginning in 1992-93. The mining expansion will be aided by European Community funding. ENUSA is also a shareholder in Cominak (Niger) and Eurodif, and has additional enrichment contracts with DOE and TENEX .

ENRESA (Empresa Nacional de Resideros Radioactivos), the national nuclear waste management company, asked the Ministry of Industry to review plans for an off-site 6,000 metric ton plant, where spent fuel could be stored for 25 to 30 years until a final repository is available.

Table 16
NUCLEAR POWER UNITS IN SPAIN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Almaraz 1	ENUSA[3]	900	PWR	1981	84	6,828
Almaraz 2	ENUSA	900	PWR	1984	83	6,800
Asco 1	ENUSA	898	PWR	1983	86	7,009
Asco 2	ENUSA	898	PWR	1986	86	6,971
Cofrentes	ENUSA	930	BWR	1985	84	7,318
Garona	ENUSA	440	BWR	1971	92	3,689
Jose Cabrera[4]	ENUSA	153	PWR	1969	85	1,189
Trillo 1	ENUSA	990	PWR	1988	84	7,643
Vandellos 1	ENUSA	480	GCR	1972	58	2,537
Vandellos 2	ENUSA	930	PWR	1988	71	6,134
Total		7,519		*(1989 Average:*	82)[5]	56,118

Units Deferred

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)[1]	Type	Percent Complete[6]
Valdecaballeros 1	ENUSA	975	BWR	71
Valdecaballeros 2	ENUSA	975	BWR	58
Total		3,750		

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] ENUSA = Empresa Nacional del Uranio SA

[4] Also known as Zorita

[5] Average does not include those units which entered commercial operation or were retired during 1989.

[6] Source: *Nuclear News*

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SWEDEN

Sweden's twelve operating reactors generated approximately 45 percent of the country's electrical power during 1989 (**Table 17**). The country's energy policy, which calls for a complete phaseout of nuclear power by 2010, limits increases in total CO_2 emissions, and bars new large-scale hydropower development, drew mounting criticism in 1989. Various labor unions in Sweden, as well as an influential faction of the ruling Social Democratic Party, accelerated their opposition to Sweden's current energy policy, because it is incompatible with their desire for continued economic growth.

Following heavily-publicized debates on energy policy in the fall of 1989, the government established a committee to reconcile opposing views of the Social Democrats and the labor groups. In early 1990, Prime Minister Carlsson announced a reorganization of the government, transferring

Table 17
NUCLEAR POWER UNITS IN SWEDEN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Barseback 1	Sydkraft	600	BWR	1975	84	4,507
Barseback 2	Sydkraft	585	BWR	1977	81	4,382
Forsmark 1	SSPB[3]	970	BWR	1980	72	6,393
Forsmark 2	SSPB	963	BWR	1981	71	6,199
Forsmark 3	SSPB	1,068	BWR	1985	74	7,650
Oskarshamn 1	OKG[4]	442	BWR	1972	82	3,315
Oskarshamn 2	OKG	605	BWR	1975	75	4,116
Oskarshamn 3	OKG	1,065	BWR	1985	84	8,126
Ringhals 1	SSPB	750	BWR	1976	74	5,050
Ringhals 2	SSPB	800	PWR	1975	52	3,857
Ringhals 3	SSPB	915	PWR	1981	73	6,146
Ringhals 4	SSPB	915	PWR	1983	70	5,859
Total		**9,678**		***(1989 Average:***	***74)***[5]	**65,600**

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] SSPB = Swedish State Power Board. Forsmark Kraftsgrupp AB (FKA) is the owner of the plant, while SSPB is the operator and fuel purchaser. SSPB owns 74.5 percent of FKA.

[4] OKG = OKG Aktiebolag

[5] Average does not include those units which entered commercial operation or were retired during 1989.

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energy matters to a former labor union leader, Rune Molin, who has voiced opposition to beginning the nuclear power phaseout in 1995 as planned.

Parliament had planned to reevaluate the nuclear phaseout decision in 1990, but this may be delayed due to changes within the government structure. However, it appears likely that the 1995 target date for the phaseout will almost certainly be delayed.

Despite nuclear power phaseout plans, Sweden, through ABB Atom, one of Sweden's largest industrial companies, continues development of the PIUS (Process Inherent Ultimate Safety) advanced reactor. Early in 1990, the Swedish/Swiss company acquired Combustion Engineering of the USA in a major move into the North American market. Earlier, ABB Atom announced a joint venture with Westinghouse to market nuclear services in Europe.

The Swedish utilities procured uranium from diverse sources during 1989 under spot and long-term arrangements. Enrichment needs were met in about equal proportions by supplies from Techsnabexport, DOE, Eurodif, Urenco, and the spot market. Sweden operates an underground storage facility for spent fuel, CLAB, and is not involved in fuel recycling.

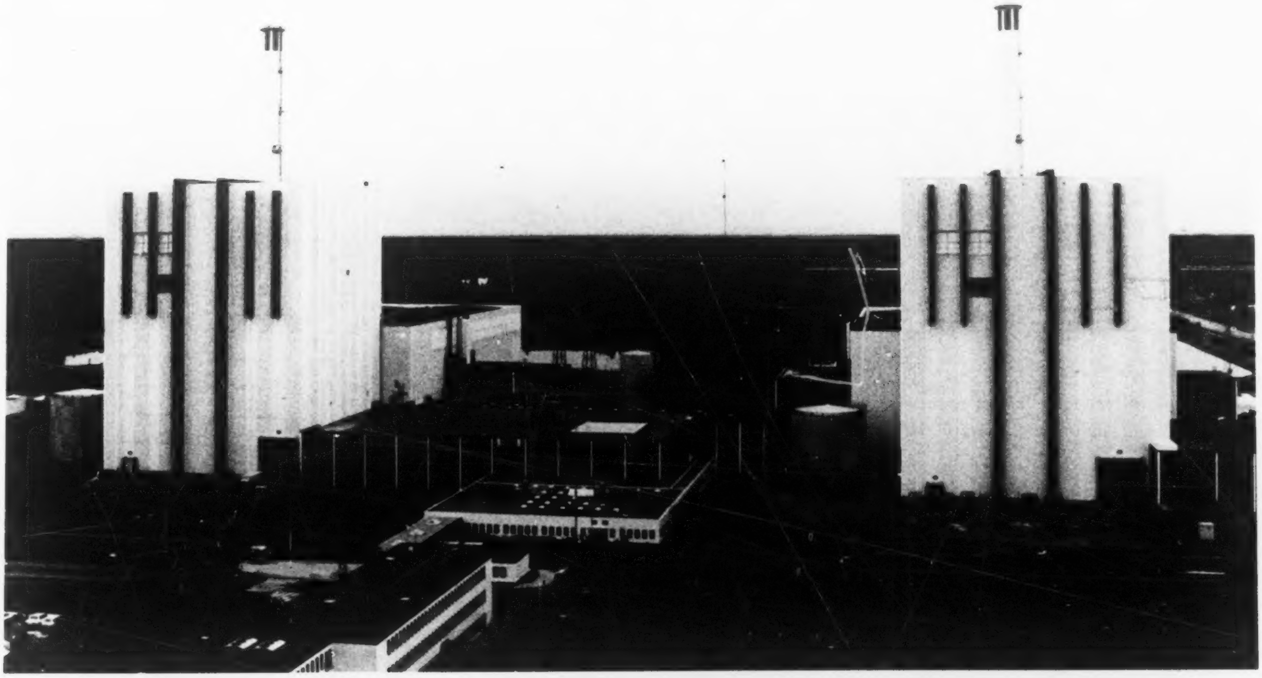

Figure 16. Two units of the three-unit Forsmark power station (2,850 MWe) operated by the Swedish State Power Board. *(Photo courtesy of the Swedish State Power Board.)*

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SWITZERLAND

Switzerland's five installed nuclear plants averaged 84 percent capacity utilization in 1989 (**Table 18**). The country relies on its nuclear units for about 40 percent of its electricity generation, obtaining the balance from hydropower. The Swiss utilities own shares in some French nuclear units and import power from France.

After more than 20 years of public opposition and controversy, the Swiss Government formally abandoned the Kaiseraugst nuclear power project on March 8, 1989, when agreement was reached on compensation to the Kaiseraugst utility consortium for the discontinuation of the project. One further nuclear project, Graben, is still officially planned, but is not considered viable by the government or the owners, led by Bernische Kraftwerk AG (BKW).

The Swiss utilities have large inventories of natural uranium, supplemented by interests in mining projects in the USA. Their enrichment needs are covered by Eurodif, Urenco, and DOE. During 1989, the utilities opened nuclear fuel relations with Techsnabexport of the Soviet Union.

NAGRA (National Cooperative for the Disposal of Radioactive Waste), the Swiss national organization responsible for evaluating, selecting, and building waste repository sites, continued boring and investigations in several areas of the country as possible sites for storage of low-, intermediate-, and high-level active wastes. A permanent depository for spent fuels will not be needed before 2020, since Switzerland will place these materials in intermediate storage for 20 to 25 years after they are returned from reprocessing. The final depository for low- and medium-level radioactive waste is scheduled to be available by 2000. At present, wastes generated by nuclear power plants are being stored temporarily on site. A special depository will be constructed at Würenlingen to centralize intermediate storage of all levels of radioactive wastes. Various groups in the country oppose the NAGRA programs, so progress on specific sites will be slow and subject to exhaustive scrutiny by public and political groups.

Table 18
NUCLEAR POWER UNITS IN SWITZERLAND

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Beznau 1	NOK[3]	350	PWR	1969	80	2,540
Beznau 2	NOK	350	PWR	1971	86	2,758
Gösgen	KKG[4]	936	PWR	1979	86	7,288
Leibstadt	KKL[5]	990	BWR	1984	85	7,768
Mühleberg	BKW[6]	326	BWR	1972	82	2,400
Total		2,952		*(1989 Average:*	84)[7]	22,754

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] NOK = Nordostschweizerische Kraftwerk AG

[4] KKG = Kernkraftwerk Gösgen-Däniken AG

[5] KKL = Kernkraftwerk Liebstadt AG

[6] BKW = Bernische Kraftwerk AG

[7] Average does not include those units which entered commercial operation or were retired during 1989.

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UNITED KINGDOM

The United Kingdom's (UK) 40 operating nuclear reactors achieved a 57-percent average capacity factor in 1989 (**Table 19**). One new unit, Torness Point 2 (660-MWe AGR) officially started commercial operation in May, while Berkeley 1, a 29-year-old, 138-MWe GCR, was shut down, having reached the end of its useful life. The 24-year-old Hinkley Point A2 set a world record of 700 days of continuous operation.

Electricity demand in the UK increased four percent in the second quarter of the year. With Torness Point 2 coming on line and a decline in coal and oil electricity production, nuclear power increased significantly to 22 percent of total electricity produced. Nevertheless, the UK imported substantial amounts of power from France; in fact, Electricité de France's (EdF) largest single export market in 1989 was the UK.

On November 9, the Thatcher government announced that the nuclear power sector of the electric utility industry would be withdrawn from the government's privatization program. The withdrawal of privatization plans followed the cancellation in September of plans to build four new PWRs, leaving Sizewell B as the only unit now under construction. In protest to the government's decisions, Lord Marshall of Goring, Chairman of Central Electricity Generating Board (CEGB) and chairman-designate of National Power, resigned on December 18.

Despite the government's announcement to curtail plans for new PWR construction, CEGB announced it would proceed with the application process for a PWR at Hinkley Point. This reactor would not be for immediate construction; rather, the application is to preserve an option for the future.

The original privatization program, announced in early 1988, has evolved into a plan to break up the Central Electricity Generating Board (CEGB) into four companies in March 1990. Operating as private entities, National Power, PowerGen, and National Grid Company will handle non-nuclear operations. Nuclear Electric, the fourth company, and Scottish Nuclear, a subdivision of South of Scotland Electricity Board, will oversee the nuclear plants and continue to operate as government entities.

In other political developments, the UK signed an agreement with West Germany on nuclear cooperation. Similar to the France-West Germany agreement signed earlier in the year, the accord emphasizes cooperation in the areas of reprocessing, fabrication, enrichment, information exchange, and transportation.

In July, CEGB Exploration (CEGBE) purchased a controlling interest in the Highland Uranium Project in Wyoming from Everest Minerals, using its US uranium company, Power Resources, Inc. The UK utilities—Nuclear Electric and Scottish Nuclear—presently have long-term contracts with Everest and Energy Fuels (USA), Olympic Dam (Australia), and Rio Algom (Canada) for most of their uranium supply.

BNFL (British Nuclear Fuels plc.), a government corporation, is the UK's fuel cycle company, operating facilities for UF6 conversion, enrichment (through its one-third participation in Urenco), powder conversion, fuel fabrication, and spent fuel reprocessing. The principal front-end facilities are located at the Springfields Works in Lancashire, England. The company holds reprocessing contracts with European and Japanese utilities and is expanding its reprocessing capacity. BNFL sought to market its expertise in nuclear services to the US Department of Defense during 1989.

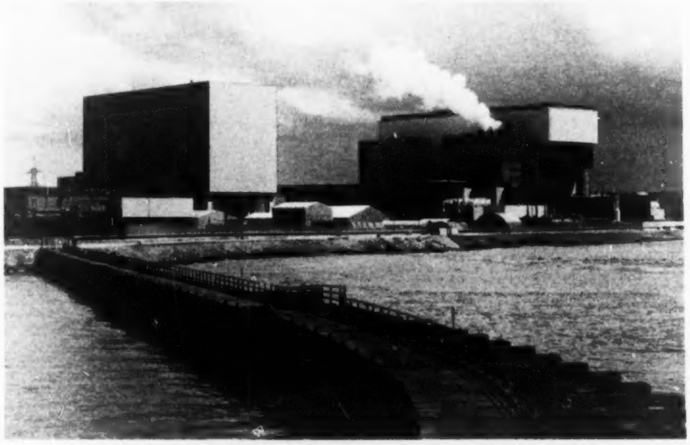

Figure 17. Heysham 1 and 2 power stations at Morecambe in Lancashire. *(Photo courtesy of Nuclear Electric.)*

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Table 19
NUCLEAR POWER STATIONS IN THE UK

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Bradwell 1, 2	CEGB[3]	123 ea.	GCR	1962	29	952
Calder Hall 1, 2, 3, 4	BNFL[4]	50 ea.	GCR	1956-59	82	1,718
Chapel Cross 1, 2, 3, 4	BNFL	48 ea.	GCR	1959-60	81	1,698
Dounreay	UKAEA[5]	234	LMFBR	1976	52	1,134
Dungeness A1, 2	CEGB	212 ea.	GCR	1965	46	2,303
Dungeness B1	CEGB	450	AGR	1985	13	763
Dungeness B2	CEGB	450	AGR	1989	—	276
Hartepool A1	CEGB	490	AGR	1987	36	2,082
Hartepool A2	CEGB	490	AGR	1987	43	2,462
Heysham A1	CEGB	485	AGR	1987	59	3,393
Heysham A2	CEGB	485	AGR	1987	48	2,760
Heysham B1	CEGB	615	AGR	1988	42	2,422
Heysham B2	CEGB	615	AGR	1989	73	4,226
Hinkley Point 1, 2	CEGB	235 ea.	GCR	1965	56	3,264
Hinkley Point B1	CEGB	560	AGR	1978	82	4,748
Hinkley Point B2	CEGB	560	AGR	1976	47	2,734
Hunterston A1, 2	SSEB[6]	150 ea.	GCR	1964	74	2,324
Hunterston B1	SSEB	575	AGR	1976	56	3,239
Hunterston B2	SSEB	575	AGR	1977	89	5,148
Oldbury 1, 2	CEGB	217 ea.	GCR	1967-68	55	3,029
Sizewell A1, 2	CEGB	210 ea.	GCR	1966	55	3,110
Torness Point 1	SSEB	645	AGR	1988	40	2,381
Torness Point 2	SSEB	645	AGR	1989	—	3,968
Trawsfynydd 1, 2	CEGB	195 ea.	GCR	1965	57	2,896
Winfrith	UKAEA	92	HWLWR	1968	52	458
Wylfa 1, 2	CEGB	420 ea.	GCR	1971-72	66	7,788
Total		**11,902**		*(1989 Average:*	57)[7]	**71,276**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[8]
Sizewell B1	CEGB	1,100	PWR	1994	30

[1] COD = Commercial Operation Date (actual or expected)

[2] Source: *Nucleonics Week*

[3] CEGB = Central Electricity Generating Board

[4] BNFL = British Nuclear Fuels plc.

[5] UKAEA = United Kingdom Atomic Energy Authority

[6] SSEB = South of Scotland Electricity Board

[7] Average does not include those units which entered commercial operation or were retired during 1989.

[8] Source: *Nuclear News*

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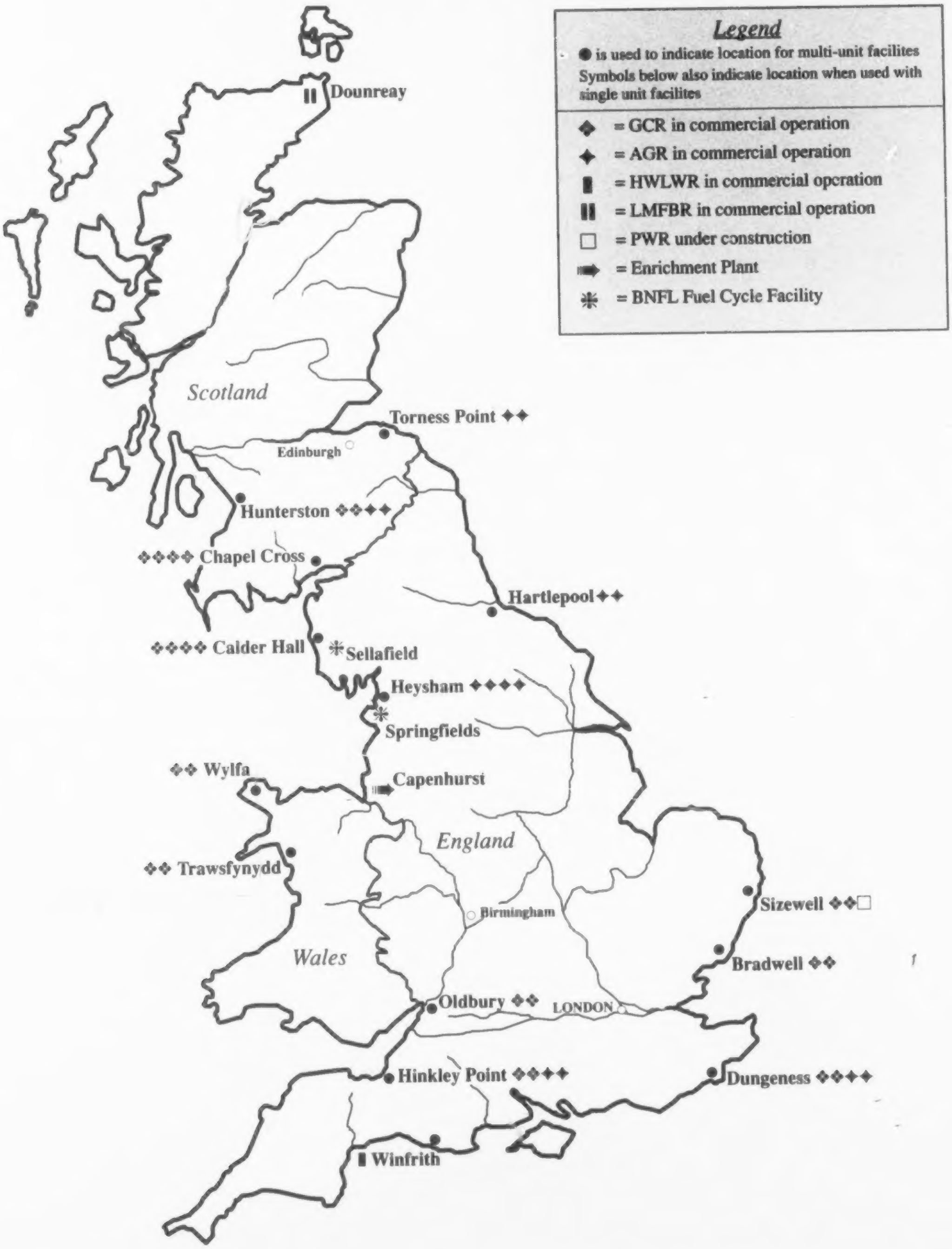
Figure 18
UNITED KINGDOM
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES


Legend
● is used to indicate location for multi-unit facilites
Symbols below also indicate location when used with single unit facilites
❖ = GCR in commercial operation
✦ = AGR in commercial operation
▮ = HWLWR in commercial operation
❚❚ = LMFBR in commercial operation
☐ = PWR under construction
➡ = Enrichment Plant
✳ = BNFL Fuel Cycle Facility
❚❚ Dounreay
Scotland
Torness Point ✦✦
Edinburgh
Hunterston ❖❖✦✦
❖❖❖❖ Chapel Cross
Hartlepool ✦✦
❖❖❖❖ Calder Hall
✳ Sellafield
Heysham ✦✦✦✦
✳ Springfields
❖❖ Wylfa
➡ Capenhurst
England
❖❖ Trawsfynydd
Birmingham
Sizewell ❖❖☐
Wales
Bradwell ❖❖
Oldbury ❖❖
LONDON
Hinkley Point ❖❖✦✦
Dungeness ❖❖✦✦
▮ Winfrith

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WEST GERMANY

Neckarwestheim 2, a 1,230-MWe Kraftwerk Union (KWU) PWR and the last of the German Convoy units, entered commercial operation in May 1989, completing West Germany's nuclear power construction program. The country's 20 operating units ran well during the year; four of the large units—Emsland, Grohnde, Gundremmingen B, and Philippsburg 2—generated more than 10,000 GWh each (**Table 20**). Nevertheless, political opposition continued to hamper the West German nuclear industry during 1989.

Plant Closures and Cancellations

In August, the North Rhine-Westphalia State government shut down the THTR-300 High Temperature Gas Reactor to avoid making additional financial contributions for the State's share of operating costs. At year-end, the plant was awaiting a special license for fuel removal. It will thereafter be placed in safe shutdown for up to 30 years before decommissioning.

In Rhineland-Palatinate, the State government rejected a plea submitted early in the year to restart the Mülheim-Kärlich reactor, which is owned by Rheinisch-Westfälisches Elektrizitätswerk AG (RWE). (RWE officially changed its name to RWE AG in the first quarter of 1990, and the company operating all power plants is called RWE Energie AG.) The 1,219-MWe PWR had been shut down by court action in September 1988. The court found that the unit had not been built in the precise location set forth in the original construction permit issued in 1972. The State upheld the Court's finding that the owners had to apply for a new license, which subjected the proceedings to a full review and public hearings. By year-end, it appeared that all licensing and legal matters had been satisfactorily completed and documented, so the new permit for operation should be granted in 1990.

A radioactive leak at Biblis resulted in a long shutdown, and Würgassen, one of West Germany's oldest nuclear power plants, was shut down early in 1990 due to concerns about fire protection measures.

The North Rhine-Westphalia State Government denied the Kalkar Fast Breeder Reactor an operating license because of alleged safety concerns. The Federal Government's view, however, is that all testing of the plant's systems has been completed satisfactorily and that there is no undue risk in operation. A resolution of this impasse is probable in 1990.

Wackersdorf

After years of controversy, the Wackersdorf reprocessing project was finally cancelled in June. Both France and the United Kingdom (UK) offered to reprocess West German spent fuel at costs estimated to be less than Wackersdorf. Late in the year, the Federal Government determined that reprocessing within the existing European Community facilities at La Hague (France) and Sellafield (UK) plants would satisfy the German Atomic Law requirement that the utilities have reprocessing contracts.

Due to the estimated cost savings arising from the Wackersdorf cancellation and the strong overall performance by most operating units, several West German utilities were able to lower their power rates. For example, Bayernwerk AG reduced its rates by five percent to major industrial users. For the average consumer, there has been no increase in electricity rates since 1983.

Nuclear Fuel Procurement

The West German utilities continued to support a geographically diversified supply base during 1989. Several of the utilities made substantial spot purchases. Uranerzbergbau (UEB) remained the primary German uranium producer through its interest in the Key Lake project in Canada. Urenco is the leading enrichment supplier to the German utilities, followed by Techsnabexport (TENEX) and DOE.

Late in the year the German Ministry for Research and Technology (BMFT) began the liquidation of the West German government uranium stockpile. The stockpile, consisting of several hundred tons of enriched uranium, was acquired by West Germany from the US Government in three purchases during the 1970s. During 1989, the government sold a portion of the stockpile to Nukem GmbH, a West German trader, to raise cash. The sale, the largest nuclear fuel inventory liquidation in the world in 1989, involved material valued at 100 million Deutschemarks ($55 million).

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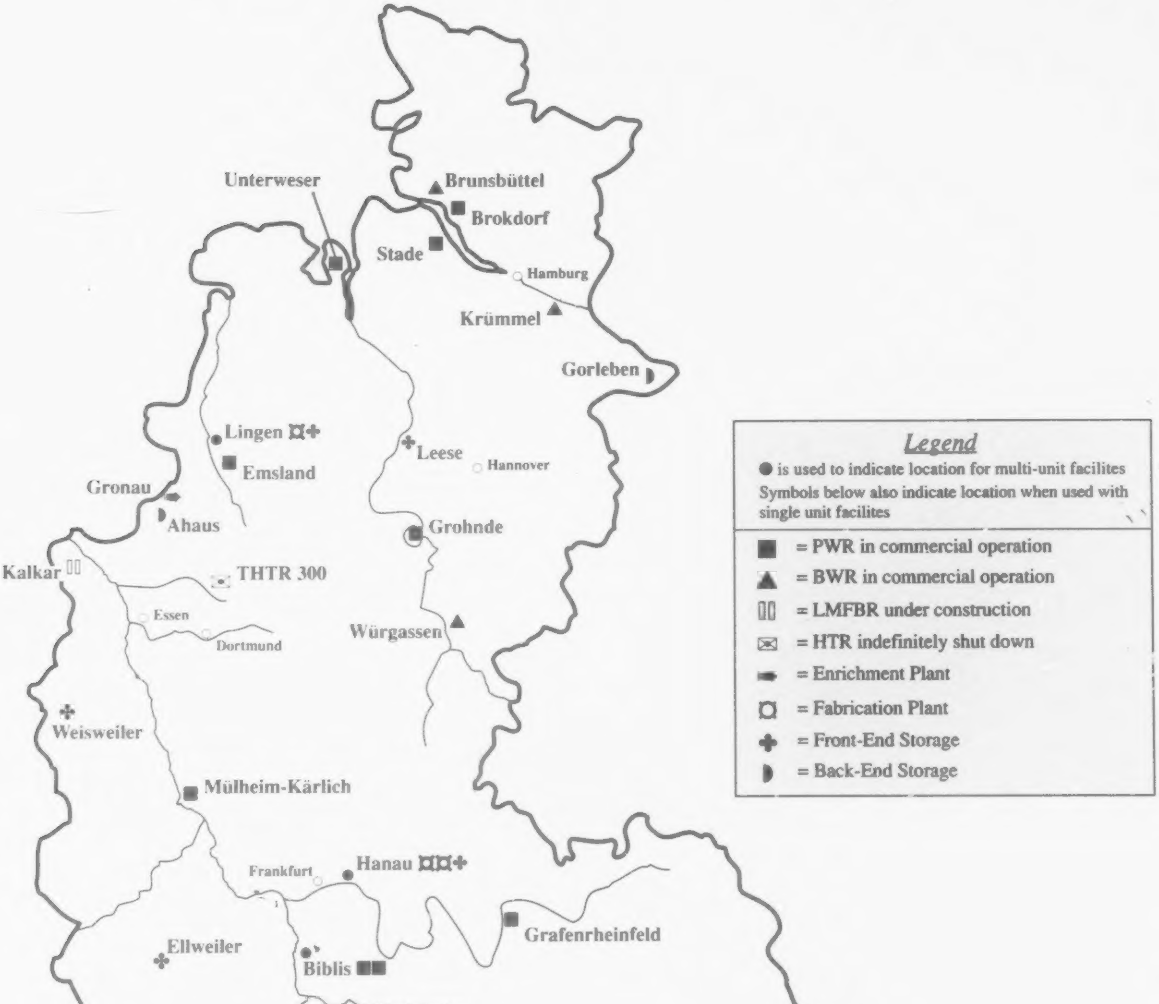
Figure 19
WEST GERMANY
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES


Unterweser
Brunsbüttel
Brokdorf
Stade
Hamburg
Krümmel
Gorleben
Lingen
Emsland
Leese
Hannover
Gronau
Ahaus
Grohnde
Kalkar
THTR 300
Essen
Dortmund
Würgassen
Weisweiler
Mülheim-Kärlich
Frankfurt
Hanau
Grafenrheinfeld
Ellweiler
Biblis
Obrigheim
Philippsburg
Neckarwestheim
Stuttgart
Gundremmingen
Isar
Munich
Legend
● is used to indicate location for multi-unit facilites
Symbols below also indicate location when used with single unit facilites
■ = PWR in commercial operation
▲ = BWR in commercial operation
▯▯ = LMFBR under construction
⊠ = HTR indefinitely shut down
➡ = Enrichment Plant
◘ = Fabrication Plant
✚ = Front-End Storage
◗ = Back-End Storage

NUEXCO

Table 20
NUCLEAR POWER UNITS IN WEST GERMANY

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Biblis A	RWE[3]	1,146	PWR	1975	65	6,830
Biblis B	RWE	1,240	PWR	1977	49	5,523
Brokdorf	PREAG[4]	1,326	PWR	1986	77	9,456
Brunsbüttel	HEW[5]	771	BWR	1977	61	4,296
Emsland	VEW[6]	1,242	PWR	1988	90	10,409
Grafenrheinfeld	BAG[7]	1,235	PWR	1982	87	9,914
Grohnde	PREAG	1,300	PWR	1985	88	10,467
Gundremmingen B	RWE	1,240	BWR	1984	89	10,198
Gundremmingen C	RWE	1,248	BWR	1985	72	8,274
Isar 1	BAG	870	BWR	1979	69	5,451
Isar 2	BAG	1,310	PWR	1988	68	8,276
Krümmel	HEW	1,260	BWR	1984	75	8,629
Mülheim-Kärlich	RWE	1,219	PWR	1987	0	0
Neckarwestheim 1	GKN[8]	795	PWR	1976	58	4,352
Neckarwestheim 2	GKN	1,230	PWR	1989	—	9,506
Obrigheim 1	KWO[9]	340	PWR	1969	86	2,689
Philippsburg 1	BW/EVS[10]	864	BWR	1980	82	6,456
Philippsburg 2	BW/EVS	1,268	PWR	1985	86	10,190
Stade	PREAG	640	PWR	1972	75	4,402
THTR 300	VEW	296	HTR	1987	0	0
Unterweser	PREAG	1,230	PWR	1979	86	9,763
Würgassen	PREAG	640	BWR	1975	68	3,971
Total		**22,710**		***(1989 Average:***	**70)[11]**	**149,052**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete
Kalkar	SBK[12]	245	LMFBR	Indefinite	100

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] RWE = RWE Energie AG

[4] PREAG = Preussenelektra AG

[5] HEW = Hamburgische Elektricitätswerke AG

[6] VEW = Vereinigte Elektrizitätswerke Westfalen AG

[7] BAG = Bayernwerk AG

[8] GKN = Gemeinschaftskernkraftwerk Neckar GmbH

[9] KWO = Kernkraftwerk Obrigheim GmbH

[10] BW / EVS = Badenwerk AG / Energieversorgung Schwaben AG

[11] Average does not include those units which entered commercial operation or were retired during 1989.

[12] SBK = Schnell-Brüter Kernkraftwerksgesellschaft mbH

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Figure 20. Neckarwestheim 1 and 2. *(Photo courtesy of GKN.)*

Two West German utilities, RWE Energie AG and Kernkraftwerk Philippsburg (KKP), as well as Preussenelektra (PREAG) through the affiliated company Urangesellschaft mbh (UG), concluded negotiations with ERA of Australia regarding the extension of long-term supply contracts for the 1990s. RWE terminated its ERA agreement after 1990, and PREAG exercised its right to cease accepting deliveries of ERA material from UG after 1991. However, KKP and UG each agreed to take one additional delivery in 1991 at a reduced price.

Kraftwerk Union (KWU), a wholly-owned subsidiary of Siemens AG, and Framatome SA of France, formed a jointly-owned company, Nuclear Power International, to further develop services and export PWRs outside France and West Germany. Steag AG increased its ownership in UG from 33-1/3 percent to 55 percent. In September, UG and Steag Kernenergie Gmbh, announced the consolidation of their respective nuclear fuel trading activities, to be headquartered in UG's Frankfurt office.

YUGOSLAVIA

Yugoslavia has one operating nuclear power unit, a Westinghouse 632-MWe PWR at Krsko, which entered commercial operation in November 1983. Krsko provides approximately five percent of Yugoslavia's total electrical production, and a much larger portion of power to the northern region including the cities of Ljubljana and Zagreb. Plans for a second nuclear power station at Prevlaka have been stalled as a result of Yugoslavia's high foreign debt, slow economic growth, and emerging environmental movement. In June, the Federal Parliament passed a law indefinitely prohibiting nuclear power plant construction.

Yugoslavia's only uranium mine, located west of Ljubljana near the Austrian border, produced approximately 220 thousand pounds equivalent U_3O_8 during 1989. Production costs are high, and the operation probably will be closed during 1990, as Krsko seeks lower-cost long-term supplies. Enrichment requirements for Krsko are provided by DOE for 70 percent, and by TENEX for 30 percent. ■

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FAR EAST

Japan
South Korea
China
Pakistan
Taiwan
India
Philippines
Thailand
Indonesia

The Far East continues to be an area of rapid economic growth, fostering the need for further nuclear power development. Japan added two nuclear units to its grid in 1989, and South Korea and India each added one. Furthermore, Korea Electric Power Corporation (KEPCO) announced plans to build three new nuclear plants, one CANDU and two PWRs. Japan announced plans for one more nuclear plant, and positive steps seemed imminent for Taiwan, Indonesia and Thailand.

Japan began full-scale operation of a prototype enrichment facility during 1989, and commissioned a second prototype plant. Japan resumed operations at the Tokai reprocessing plant, which had been closed for modifications since June 1988. South Korea began producing fuel at its new fabrication facility. During the year, China positioned inventories of natural uranium concentrates at converters in Europe and the USA, thereby strengthening its marketing and sales efforts in those areas.

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CHINA

Domestic upheaval and declining market prices made 1989 a trying year for China National Nuclear Corporation (CNNC). The political unrest in China and the government crackdown which followed caused only minor slowdowns in construction work at the Qinshan nuclear plant near Shanghai and the Daya Bay plant near Hong Kong. Qinshan is now scheduled for completion in 1991. Daya Bay 1 should begin operating in the fall of 1992, and the second unit should follow one year later.

China aims to have 6,000 MWe of nuclear power capacity in operation by the year 2000, but progress toward that goal was slow in 1989. A plan to build two more units at the Qinshan site using technology from France or West Germany was shelved due to high costs. China now plans to use its own technology for those two units.

CNNC held discussions with the Soviet Union regarding the possible barter purchase of two VVER 1,000-MWe PWRs for Lioning Province in northeastern China. CNNC is also considering two additional PWRs for southern China.

China's uranium production capacity, formerly devoted to military uses, falls in the range of about five to ten million pounds equivalent U_3O_8 per year. Under current market conditions, perhaps two to three million pounds per year may be available for sale. But in 1989, politics and low market prices hampered the marketing and sales efforts of CNNC's nuclear fuel export subsidiary China Nuclear Energy Industry Corp. (CNEIC). Because of the mid-year violence in Beijing, some customers declined to purchase Chinese uranium. Others felt that refusing to buy Chinese uranium would only hurt advocates of democracy. However, the continuing decline in uranium prices caused CNEIC's greatest problems. During the second half of the year, CNEIC withdrew from the spot market and turned its attention to long-term sales offers. Falling SWU prices also hurt its efforts to sell an inventory of EUP.

In July, CNEIC shipped a single lot of 2.5 million pounds equivalent U_3O_8 from Shanghai to the USA, storing roughly equal amounts at the Allied-Signal and Sequoyah Fuels conversion facilities. By year-end, half the material had been sold. During the year CNEIC also positioned concentrate inventories at converters in Europe. These stocks will be expanded in 1990.

CNNC modified the Lanzhou enrichment plant to increase its capacity by 50 percent, and to utilize fresh, rather than reprocessed, feed material. CNNC will devote the plant's output to the initial cores of the Daya Bay units.

China has indicated its intention to build two reprocessing plants—one in Zhejiang to serve the Qinshan and Daya Bay units, and one in the Gobi desert. Excess capacity could be used to accept spent fuel from other countries for long-term storage or reprocessing. However, negotiations with European utilities have apparently broken down over the price quoted by China.

INDIA

India has seven operating nuclear plants with total net electric generating capacity of 1,374 MWe (**Table 21**). One unit, NAPP 1 (Narora Atomic Power Plant), a 220–MWe pressurized heavy water reactor (PHWR), entered service in July 1989. NAPP 2 and KAPP 1 are scheduled for commercial operation in 1991. In 1989, India announced plans to increase its nuclear generating capacity to 10,000 MWe by the year 2000. This aggressive program includes twelve new nuclear power plants, a second prototype fast breeder reactor, domestically-supplied uranium and heavy water, and three new nuclear fuel plants.

In late 1988, India signed an agreement with the Soviet Union to supply two 1,000-MWe VVER-88 PWRs, which will be located in the Tamil Nadu district. The other planned nuclear power plants are CANDU types, domestically produced, and with capacities of 500 MWe or less. To support the heavy water requirements of the CANDU–type plants, two more heavy water plants are under construction at Manuguru and Hazira.

India plans to expand its nuclear fuel plant at Hyderabad, and to build two additional nuclear fuel plants at Turamidh and Palakayal. Construction continued on the Kalpakkam reprocessing plant in 1989. Also, a $10 million insurance pool was formed for nuclear plants and a proposal submitted to establish a new nuclear science center at the University of Madras.

The Madras 1 and 2 reactors were shut down for three and six months, respectively, for temporary repairs in 1989. The indigenous fast breeder test reactor (FBTR) at Kalpakkam was restarted in May after being shut down for two years following a fuel-handling accident.

India produces about 550 thousand pounds equivalent U_3O_8 per year from Jadugada, its only producing facility, consisting of two underground mines and a mill. These mines supply 90-95% of the concentrates produced in India; by-product recovery at copper mines accounts for the balance. A second mill, scheduled to start up at Turamidh in 1992, would triple India's production capacity.

Table 21
NUCLEAR POWER UNITS IN INDIA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Tarapur 1 (TAPS)	NPC[3]	150	BWR	1969	49	892
Tarapur 2 (TAPS)	NPC	150	BWR	1969	26	472
Rajasthan 1 (RAPS)	NPC	207	PHWR	1973	20	384
Rajasthan 2 (RAPS)	NPC	207	PHWR	1981	64	1,225
Kalpakkam 1 (MAPS)	NPC	220	PHWR	1984	24	492
Kalpakkam 2 (MAPS)	NPC	220	PHWR	1985	25	518
Narora 1 (NAPP)	NPC	220	PHWR	1989	—	—
Total		**1,374**		*(1989 Average:*	**34)**[4]	**3,983**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[5]
Kakrapar 1 (KAPP)	NPC	220	PHWR	1991	57
Kakrapar 2 (KAPP)	NPC	220	PHWR	1992	44
Kaiga 1	NPC	220	PHWR	1995	18
Kaiga 2	NPC	220	PHWR	1996	18
Narora 2 (NAPP)	NPC	220	PHWR	1990	85
Rajasthan 3	NPC	220	PHWR	1995	10
Rajasthan 4	NPC	220	PHWR	1996	10
Total		**1,540**			

[1] COD = Commercial Operation Date (actual or expected)

[2] Source: *Nucleonics Week*

[3] NPC = Nuclear Power Corporation (Department of Atomic Energy)

[4] Average does not include those units which entered commercial operation or were retired during 1989.

[5] Source: *Nuclear News*

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JAPAN

Japan's 37th and 38th commercial nuclear units, Shimane 2 (820-MWe BWR) and Tomari 1 (579-MWe PWR), entered commercial operation in February and June, respectively. Tomari 1, Hokkaido Electric Power Company's first nuclear power plant, posted a perfect performance record in its first six months of operation, achieving a capacity factor of 100 percent. In 1988, antinuclear groups temporarily halted construction on Tomari 1 by filing a civil suit, but the reactor's excellent performance in 1989 helped allay some of the earlier public concerns. The capacity additions of Shimane 2 and Tomari 1 raised Japan's gross reactor capacity by five percent to almost 30,000 MWe (**Table 22**).

Tokyo Electric Power Company's (TEPCO) Kashiwazaki-Kariwa Units 2 and 5 (1,045-MWe BWRs) are scheduled to begin operation in 1990; both units were 98-percent complete at year-end (**Table 23**).

TEPCO announced plans for Kashiwazaki-Kariwa 8, a 1,356-MWe Advanced BWR, although no commercial operating date has been set. Thus, Japan has 13 units planned, and 14 under construction. Of these 14 units, construction began in 1989 on three (Hamaoka 4, Shika 1, and Onagawa 2), while delays were reported for five other units (Genkai 3, Higashi Dori 1, Namie Odaka, Tomari 2, and N-1). Planned additions to nuclear generating capacity remain at almost 27,000 MWe.

The nation's monthly average capacity factor reached a high of 83 percent in August, Japan's hottest month. The average capacity factor for the year was 72 percent.

Table 22
JAPANESE ANNUAL ADDITIONS OF NUCLEAR GENERATING CAPACITY
1966-1989

Year	Capacity Addition (Gross MWe)	Total MWe at Year End
1966-1979	—	15,117
1980	0	15,117
1981	559	15,676
1982	1,666	13,342
1983	0	13,342
1984	2,514	19,856
1985	4,830	24,686
1986	0	24,686
1987	3,360	28,046
1988	0	28,046
1989	1,399	29,445

Future Government Spending

As further indication of Japan's future commitment to nuclear power, the Japanese government announced that its fiscal 1990 nuclear budget will be a sizable ¥395.5 billion (US$2.7 billion). Some of the budget components are:

	Billion Yen
◆ Funds for plant siting	106.5
◆ Commercialization of the FBR	7.4
◆ LWR efficiency development	6.5
◆ Laser technique development	2.0
◆ Verification of spent fuel storage technology	1.2
◆ Co-development funding on chemical fusion technology	0.3
◆ Concessional financing reserve (JNF & NFI)	200.0

Significant increases are also slated for public relations programs in 1990. MITI plans to double its outlay to ¥965 million (US$6.7 million), and the Science and Technology Agency will raise its public relations spending to ¥2.9 billion (US$19.9 million), five times current levels. There is so much concern within the nuclear industry about unfavorable public opinion, that its threat to the future growth of Japan's nuclear power program was the top-priority subject at the Japan Atomic Industrial Forum, Inc. (JAIF) Annual Conference in 1989. Consequently, an increased number of educational programs and presentations were given in 1989.

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Table 23
NUCLEAR POWER UNITS IN JAPAN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Fugen	PNC[3]	148	ATR	1979	63	910
Fukushima I-1	Tokyo EPC[4]	439	BWR	1971	38	1,521
Fukushima I-2	Tokyo EPC	760	BWR	1974	99	6,779
Fukushima I-3	Tokyo EPC	760	BWR	1976	86	5,921
Fukushima I-4	Tokyo EPC	760	BWR	1978	64	4,384
Fukushima I-5	Tokyo EPC	760	BWR	1978	72	4,965
Fukushima I-6	Tokyo EPC	1,067	BWR	1979	55	5,323
Fukushima II-1	Tokyo EPC	1,067	BWR	1982	68	6,535
Fukushima II-2	Tokyo EPC	1,067	BWR	1984	89	8,625
Fukushima II-3	Tokyo EPC	1,067	BWR	1985	1	134
Fukushima II-4	Tokyo EPC	1,067	BWR	1987	98	9,486
Genkai 1	Kyushu EPC	529	PWR	1975	47	2,309
Genkai 2	Kyushu EPC	529	PWR	1981	70	3,413
Hamaoka 1	Chubu EPC	515	BWR	1976	44	2,059
Hamaoka 2	Chubu EPC	815	BWR	1978	65	4,785
Hamaoka 3	Chubu EPC	1,066	BWR	1987	93	8,936
Ikata 1	Shikoku EPC	538	PWR	1977	76	3,775
Ikata 2	Shikoku EPC	538	PWR	1982	80	3,966
Kashiwazaki-Kariwa 1	Tokyo EPC	1,067	BWR	1985	70	6,751
Mihama 1	Kansai EPC	320	PWR	1970	60	1,799
Mihama 2	Kansai EPC	470	PWR	1972	80	3,522
Mihama 3	Kansai EPC	780	PWR	1976	77	5,589
Ohi 1	Kansai EPC	1,120	PWR	1979	28	2,880
Ohi 2	Kansai EPC	1,120	PWR	1979	99	10,209
Onagawa 1	Tohoku EPC	496	BWR	1984	70	3,197
Sendai 1	Kyushu EPC	846	PWR	1984	99	7,687
Sendai 2	Kyushu EPC	846	PWR	1985	67	5,206
Shimane 1	Chugoku EPC	439	BWR	1974	68	2,740
Shimane 2	Chugoku EPC	791	BWR	1989	—	5,670
Takahama 1	Kansai EPC[4]	780	PWR	1974	71	5,152
Takahama 2	Kansai EPC	780	PWR	1974	58	4,222
Takahama 3	Kansai EPC	830	PWR	1985	81	6,205
Takahama 4	Kansai EPC	830	PWR	1985	93	7,052
Tokai 1[5]	JAPC[6]	159	GCR	1966	34	489
Tokai 2	JAPC	1,080	BWR	1978	91	8,747
Tomari 1	Hokkaido EPC	550	PWR	1989	—	2,682
Tsuruga 1	JAPC	340	BWR	1970	82	2,577
Tsuruga 2	JAPC	1,115	PWR	1987	77	7,830
Total		**28,251**		***(1989 Average:***	**72)**[7]	**184,032**

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[1] COD = Commercial Operation Date

[2] Source: *Atoms In Japan*

[3] PNC = Power Reactor and Nuclear Fuel Development Corporation

[4] EPC = Electric Power Company

[5] Will be decommissioned after 1995.

[6] JAPC = Japan Atomic Power Company

[7] Average does not include those units which entered commercial operation or were retired during 1989.

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Table 23
NUCLEAR POWER UNITS IN JAPAN
(continued)

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[2]
Genkai 3	Kyushu EPC[3]	1,121	PWR	1994	43
Genkai 4	Kyushu EPC	1,121	PWR	1997	10
Hamaoka 4	Chubu EPC	1,045	BWR	1993	24
Ikata 3	Shikoku EPC	846	PWR	1995	34
Kashiwazaki-Kariwa 2	Tokyo EPC	1,045	BWR	1990	98
Kashiwazaki-Kariwa 3	Tokyo EPC	1,045	BWR	1993	30
Kashiwazaki-Kariwa 4	Tokyo EPC	1,045	BWR	1994	14
Kashiwazaki-Kariwa 5	Tokyo EPC	1,045	BWR	1990	98
Monju	PNC[4]	280	LMFBR	1993	78
Ohi 3	Kansai EPC	1,121	PWR	1991	48
Ohi 4	Kansai EPC	1,121	PWR	1992	17
Onagawa 2	Tohoku EPC	784	BWR	1996	3
Shika 1	Hokuriku EPC	513	BWR	1993	34
Tomari 2	Hokkaido EPC	550	PWR	1991	93
Total		12,682			

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]
Ashihama 1[5]	Chubu EPC	1,045	BWR	1997
Ashihama 2[5]	Chubu EPC	1,045	BWR	1998
Higashi Dori 1[5]	Tohoku EPC	1,045	BWR	1999
Hohoku 1[5]	Chugoku EPC	1,045	BWR	1997
Hohoku 2[5]	Chugoku EPC	1,045	BWR	1999
Kashiwazaki-Kariwa 6	Tokyo EPC	1,356	BWR	1996
Kashiwazaki-Kariwa 7	Tokyo EPC	1,356	BWR	1998
Kashiwazaki-Kariwa 8	Tokyo EPC	1,356	BWR	Unspecified
Maki 1	Tohoku EPC	784	BWR	1999
Namie-Odaka[5]	Tohoku EPC	796	BWR	2003
N1[5]	Hokuriku EPC	1,100	PWR	2003
Ohma[5]	EPDC[6]	570	ATR	1997
Oura 1[5]	Kansai EPC	1,200	PWR	1996
Total		13,743		

[1] COD = Commercial Operation Date (expected)

[2] Source: *Atoms In Japan*

[3] EPC = Electric Power Company

[4] PNC = Power Reactor and Nuclear Fuel Development Corporation

[5] No authorization for development planning.

[6] EPDC = Electric Power Development Company

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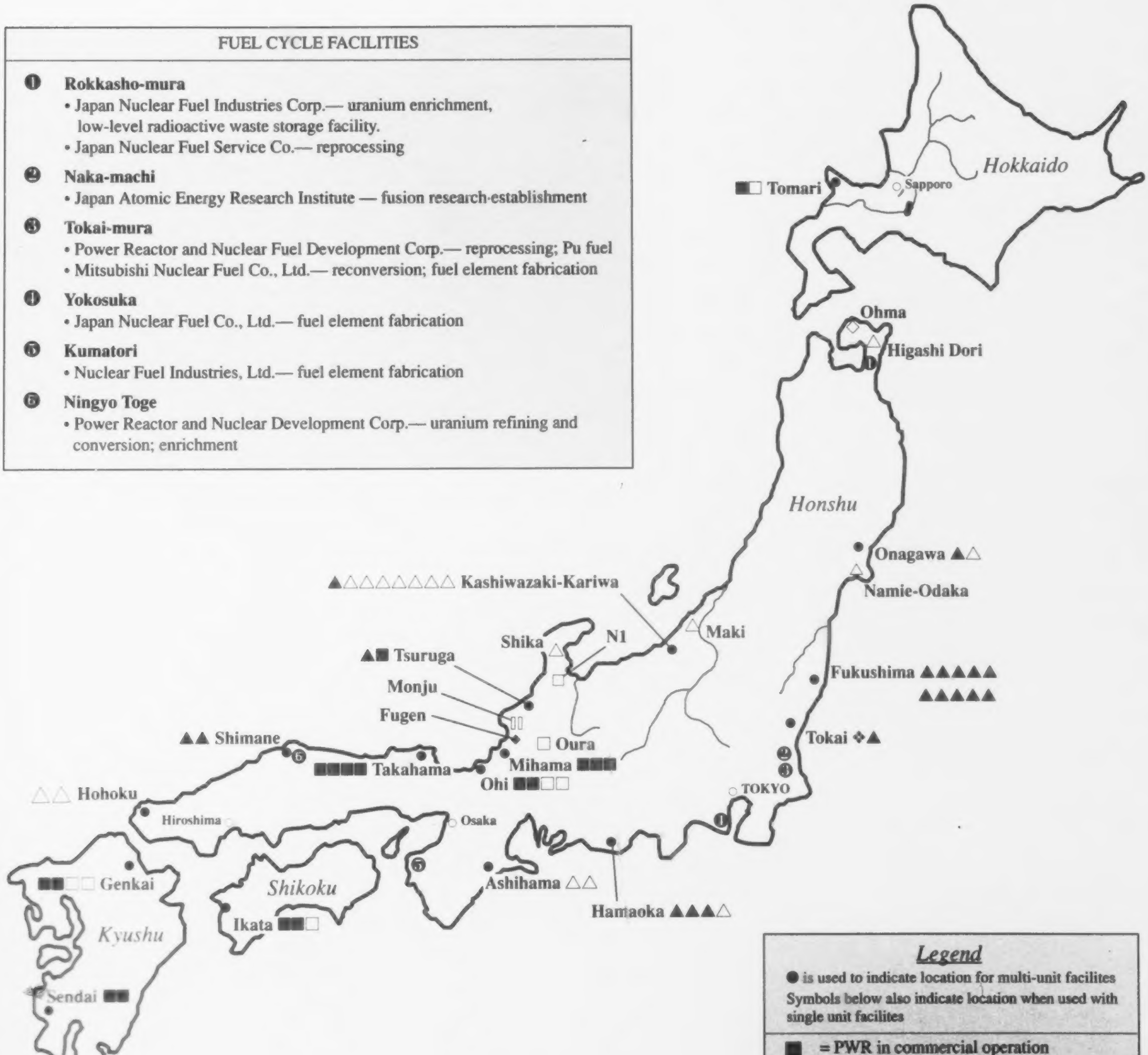
NUEXCO

FAR EAST

Figure 21
JAPAN
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES


■□ Tomari
Sapporo
Hokkaido
Ohma
Higashi Dori
Honshu
Onagawa ▲△
Namie-Odaka
▲△△△△△△△ Kashiwazaki-Kariwa
Maki
N1
Shika
▲■ Tsuruga
Monju
Fugen
Fukushima ▲▲▲▲▲ ▲▲▲▲▲
Tokai ❖▲
TOKYO
▲▲ Shimane
□ Oura
■■■■ Takahama
Mihama ■■■
Ohi ■■□□
△△ Hohoku
Hiroshima
Osaka
Ashihama △△
Hamaoka ▲▲▲△
■■□□ Genkai
Shikoku
Ikata ■■□
Kyushu
Sendai ■■

FUEL CYCLE FACILITIES

❶ **Rokkasho-mura**
- Japan Nuclear Fuel Industries Corp.— uranium enrichment, low-level radioactive waste storage facility.
- Japan Nuclear Fuel Service Co.— reprocessing

❷ **Naka-machi**
- Japan Atomic Energy Research Institute — fusion research establishment

❸ **Tokai-mura**
- Power Reactor and Nuclear Fuel Development Corp.— reprocessing; Pu fuel
- Mitsubishi Nuclear Fuel Co., Ltd.— reconversion; fuel element fabrication

❹ **Yokosuka**
- Japan Nuclear Fuel Co., Ltd.— fuel element fabrication

❺ **Kumatori**
- Nuclear Fuel Industries, Ltd.— fuel element fabrication

❻ **Ningyo Toge**
- Power Reactor and Nuclear Development Corp.— uranium refining and conversion; enrichment

Legend

● is used to indicate location for multi-unit facilites Symbols below also indicate location when used with single unit facilites

■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
❖ = GCR in commercial operation
◆ = ATR in commercial operation
◇ = ATR under construction or planned
▯▯ = LMFBR under construction or planned

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Energy Costs and Demand

Nuclear power maintained its lead as the least expensive primary electric generation source in Japan. According to the Ministry of International Trade and Industry's (MITI) latest study, cost per kilowatt-hour remained at ¥9 (US$0.06). Costs of other generation sources [liquid natural gas (LNG), coal, and oil] declined somewhat, but not enough to overtake nuclear energy. Hydropower generation costs were unchanged at ¥13 (US$0.09) per kWh.

Plant construction costs, however, yielded a different result. Hydropower was highest, with costs of ¥640,000 (US$4,410) per kWh, followed by nuclear at ¥310,000 (US$2,140), and coal at ¥230,000 (US$1,590). Liquid natural gas was at ¥200,000 (US$1,380) and oil was ¥190,000 (US$1,310). The MITI report takes into account the four most recent operating plants in each generating category.

This report, along with 1989's record electricity demands, could indicate an even brighter future for nuclear power in Japan. During 1989, demand was stronger than expected for all nine major utilities, and in January 1990 TEPCO reported a 10.7 percent increase. TEPCO's annual growth rate in demand is expected to exceed 7.3 percent (5 percent was projected) by fiscal year end.

Political Developments

The past year was unusually turbulent for the Japanese government, as scandals dominated the news. The responsibilities of the Prime Minister were handed from Mr. Takeshita, to Mr. Uno, to Mr. Kaifu; on the local level, the Liberal Democratic Party (LDP) suffered a serious electoral setback and lost its majority. In Upper House elections, three pronuclear candidates were unseated in Aomori (site of the Rokkasho-mura facilities), and the Fukui and Fukushima districts. Despite these losses and a strong public opposition, licensing applications for the Rokkasho-mura facilities were approved and construction is scheduled to begin in 1991.

Other Developments

In Japan's continuing efforts to complete its domestic fuel cycle capabilities, the second enrichment prototype facility (DOP 2, 100,000 SWU per year) was commissioned at Ningyo-Toge, and the Nuclear Fuel Development Corporation (NFDC) began full-scale operation of its prototype facility in Okayama. Japan expects to produce three million SWU per year by 2000, enough to satisfy more than 40 percent of Japan's demand by that time.

The Japanese government issued a white paper in November to the industrialized countries of the world urging them to rely on "clean" nuclear power. The message was strengthened when projections of world carbon dioxide levels, as well as their potential to significantly contribute to the greenhouse effect, were released.

Japan also released a nine-point severity scale for rating nuclear mishaps. Prompted by the Chernobyl accident, the scale uses several globally recognized thresholds from Chernobyl studies. The use of this more objective scale is expected to improve the Japanese public's awareness and understanding of nuclear incidents.

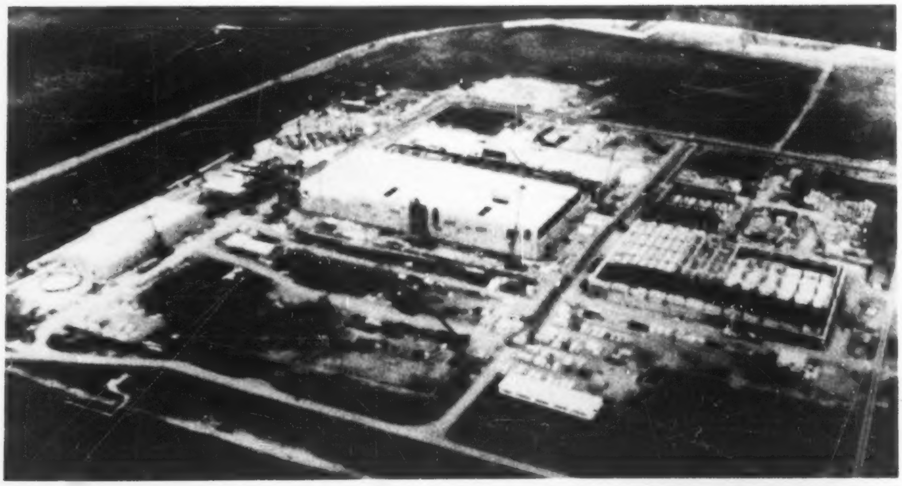

Figure 22. Commercial uranium enrichment plant under construction at Rokkasho-mura. (Reprinted by permission of *Atoms in Japan*.)

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SOUTH KOREA

Korea Electric Power Corporation (KEPCO) connected an additional PWR to the grid in September 1989, increasing nuclear power's share of electricity generation in South Korea to just over 50 percent—among the highest in the world. The new unit, Uljin 2, is the sister unit to Uljin 1, which began operating in 1988. Framatome supplied both units, but Korean firms were heavily involved in the construction of each unit. The addition of Uljin 2 brings Korea's net nuclear capacity to 7,266 MWe, which is about one-third of KEPCO's total generating capacity (**Table 24**).

Although no additional nuclear plant construction activity was underway during the year, two back-ordered units, the

Table 24
NUCLEAR POWER UNITS IN SOUTH KOREA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Kori 1	KEPCO[3]	556	PWR	1978	57	2,903
Kori 2	KEPCO	605	PWR	1983	94	5,375
Kori 3	KEPCO	895	PWR	1985	83	6,873
Kori 4	KEPCO	895	PWR	1986	77	6,435
Uljin 1	KEPCO	943	PWR	1988	65	5,422
Uljin 2	KEPCO	943	PWR	1989	—	2,242
Wolsong 1	KEPCO	629	HWR	1983	91	5,411
Yonggwang 1	KEPCO	900	PWR	1986	81	6,740
Yonggwang 2	KEPCO	900	PWR	1987	72	5,961
Total		**7,266**		*(1989 Average:*	**77)**[4]	**47,362**

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete
Yonggwang 3	KEPCO	943	PWR	1995	planned
Yonggwang 4	KEPCO	943	PWR	1996	planned
Wolsong 2	KEPCO	700	HWR	1997	planned
Uljin 3	KEPCO	943	PWR	1998	planned
Uljin 4	KEPCO	943	PWR	1999	planned
Total		**4,472**			

[1] COD = Commercial Operation Date (actual or expected)

[2] Source: *Nucleonics Week*

[3] KEPCO = Korea Electric Power Corporation

[4] Average does not include those units which entered commercial operation or were retired during 1989.

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943-MWe net PWRs ordered in 1987 from Combustion Engineering, are ready to begin construction. Preliminary site work for these units (designated as Yonggwang Units 3 and 4) was finished during 1989, and construction on the first began at year-end. The site had been the scene of several antinuclear protests during 1989.

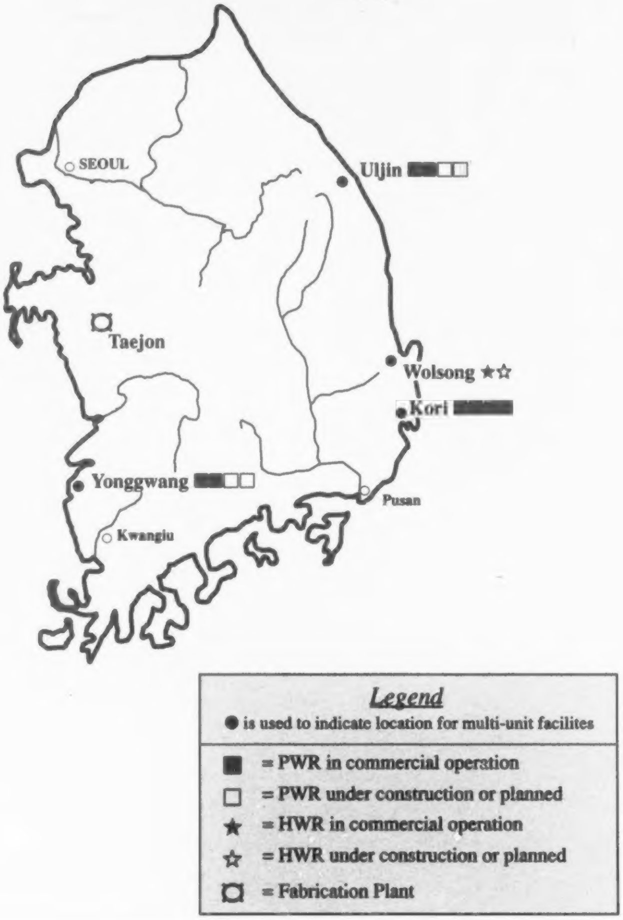
In October, KEPCO announced plans to build three more nuclear plants. Construction is expected to begin in 1991 on the second CANDU reactor at the Wolsong site, and on two 1,000-MWe PWRs. Designed by Korean companies in cooperation with Combustion Engineering, General Electric, and Sargent & Lundy, they will be built at the Uljin site.

Uranium Supply

During 1989, a government audit team focused attention on KEPCO's nuclear fuel purchase program. Its report, which was being reviewed at year-end, recommended diversification of supply sources (especially with the Soviet Union and China) and greater use of the spot market to obtain lower fuel costs.

KEPCO spent much of the year renegotiating its long-term uranium supply contracts, receiving some concessions from all its suppliers. In addition, discussions have been held at the government level between the Soviet Union and South Korea. An offer from TENEX to sell EUP at prices well below KEPCO's existing long-term contracts was being carefully considered at year-end, and lead to a long-term deal involving 40 MTU of EUP per year. This contract was approved by the South Korean government in March 1990.

Figure 23
SOUTH KOREA
NUCLEAR POWER UNITS
AND FUEL CYCLE FACILITIES


SEOUL
Uljin ■■□□
Taejon
Wolsong ★☆
Kori ■■■■
Yonggwang ■■□□
Pusan
Kwangju
Legend
● is used to indicate location for multi-unit facilites
■ = PWR in commercial operation
□ = PWR under construction or planned
★ = HWR in commercial operation
☆ = HWR under construction or planned
= Fabrication Plant

KEPCO's uranium supply strategy includes equity participation in uranium projects. This includes a two-percent (non-voting) share in the Cigar Lake project, participation in the Leyou-North project in Gabon, and a ten-percent share of the Crow Butte project in the USA.

Fuel Cycle Facilities

As part of Korea's overall plan to achieve self-sufficiency in nuclear technology, its work continued on the final construction and startup of a nuclear fuel fabrication plant at Taejon. Kraftwerk Union is providing the basic design, in collaboration with Siemens Brennelementewerk Hanau (SBH), formerly Reaktor-Brennelement Union (RBU).

Korea Nuclear Fuel Company, a KEPCO subsidiary, began operating the plant in January 1989, using UO_2 supplied by SBH. The plant's UF_6-to-UO_2 conversion line was under construction for most of 1989, but was ready for startup testing by the end of the year. When fully operational, the fabrication plant should be able to fulfill all the fabrication requirements for Korea's PWRs.

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TAIWAN

Taiwan Power Corporation's (Taipower) nuclear program remained stable during 1989. Taipower's six nuclear units each operated at lower capacity factors than 1988. Its seventh and eighth units are still deferred due to public opposition. Late in the year, Taipower discontinued its participation in the spot uranium market.

Nuclear Power Program

Taipower's six nuclear generating units (**Table 25**) have a combined net capacity of 4,884 MWe. They achieved an average capacity factor for 1989 of 63 percent, down from 68 percent in 1988.

Taiwan's nuclear power construction program has been beset by uncertainty and indecision since 1985,

Figure 24. Kuosheng nuclear station (two 948-MWe BWRs). *(Photo courtesy of Taipower)*

Table 25
NUCLEAR POWER UNITS IN TAIWAN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Chinshan 1	Taipower[3]	604	BWR	1978	53	2,922
Chinshan 2	Taipower	604	BWR	1979	58	3,208
Kuosheng 1	Taipower	948	BWR	1981	64	5,518
Kuosheng 2	Taipower	948	BWR	1983	63	5,422
Maanshan 1	Taipower	890	PWR	1984	68	5,675
Maanshan 2	Taipower	890	PWR	1985	66	5,532
Total		**4,884**		***(1989 Average:***	**63)**[4]	**28,277**

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] Taipower = Taiwan Power Corporation

[4] Average does not include those units which entered commercial operation or were retired during 1989.

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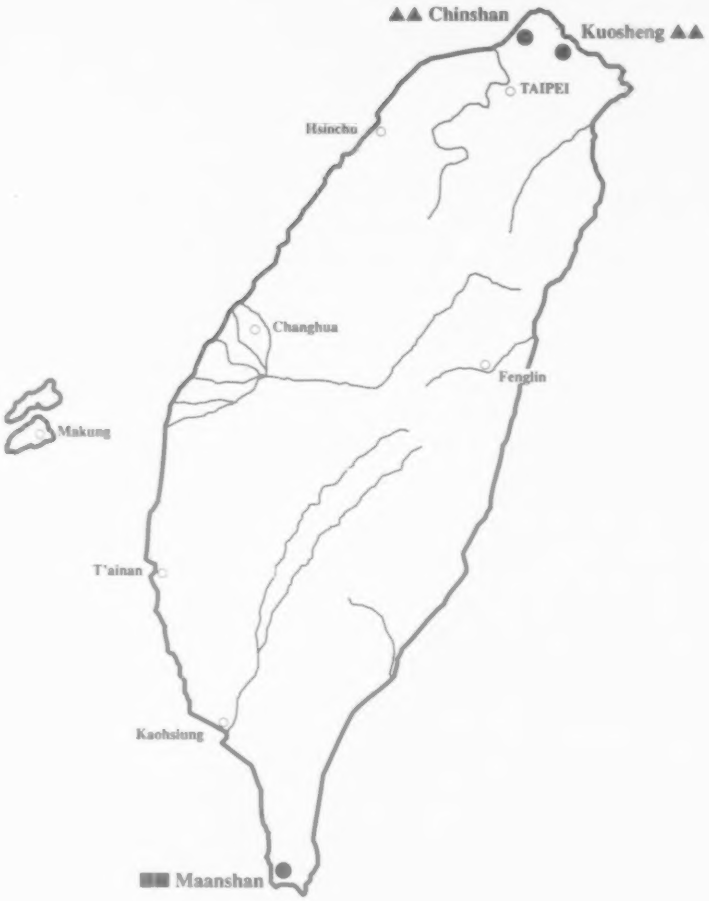
when the Ministry of Economic Affairs suspended plans for the country's seventh and eighth nuclear units, which had been planned for the Yenliao site. In the interim, Taipower has expended a great deal of effort aimed at easing public concerns about nuclear power. Lessened public concern is a prerequisite for the government's approval of any further nuclear units. The ruling party is hoping to foreclose any possibility of nuclear power becoming a political issue, especially as the opposition parties gain even greater support. Toward the end of the year, Premier Lee Huan seemed likely to take a more public stance on the nuclear issue, probably in support of continued growth in Taiwan's nuclear program.

With six nuclear units operating, Taipower's uranium requirements are less than two million pounds equivalent U_3O_8 annually. Taipower's long-term strategy is to cover 30 percent of its needs through equity participation in uranium exploration and development programs. It has one such program with Union Pacific Resources in the USA. The remaining 70 percent of its needs are to be met through both spot and long-term uranium purchases. Taipower made several spot market uranium purchases in 1988 and 1989, but was not active in the spot market near the end of 1989.

All of Taipower's nuclear fuel needs are presently supplied from overseas sources. However, Taiwan plans to develop a domestic fuel fabrication capability when its nuclear power program expands sufficiently.

Figure 25
TAIWAN
NUCLEAR POWER UNITS



Legend
● is used to indicate location for multi-unit facilites
■ = PWR in commercial operation
▲ = BWR in commercial operation

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OTHER COUNTRIES

Philippines

The Philippines' sole nuclear power plant has never operated because of political opposition associated with allegations of bribery to former government officials and poor workmanship during construction. The Philippine government lawsuit, filed in late 1988 against Westinghouse and Burns & Roe, the nuclear vendor and architect/engineer for the plant, continued to move slowly through the courts.

In November 1989, over a year after the US Export-Import Bank released liens against the one reload of fuel purchased for inventory, the Philippines issued a bid invitation for the inventory/reload fuel assemblies. However, the Philippine government established a minimum bid level of US$13.3 million, well above market values, thereby precluding any successful bids.

Pakistan

Pakistan's only nuclear power plant (Kanupp) resumed operating in October 1989 after a 15-month shutdown. The 137-MWe net plant was shut down in July 1988 for recommissioning, 16 years after its first commercial operation.

In November 1989, China agreed to supply a 300-MWe PWR to Pakistan for construction at Chasma in Northern Punjab. Pakistan also concluded an agreement in early 1990 to purchase an additional LWR from France. This agreement ended a 14-year embargo on nuclear technology from France to Pakistan. In late December, Pakistan's Atomic Energy Commission decided to abandon its only uranium mine due to severe localized violence.

Indonesia and Thailand

Indonesia and Thailand continue to include nuclear capacity in their energy plans. Prospects seemed to have improved considerably in Indonesia as the National Atomic Energy Agency, known as BATAN, initiated the development of Indonesia's first nuclear plant with publicly-announced government support.

In Thailand, electricity demand spurred by rapid economic growth has caused the national electric reserve margin to plummet from 35 percent in 1987 to 3 percent in 1989. This has led to renewed interest in the nuclear option for the long term, including a favorable decision at the Cabinet level and high-level discussions with nuclear plant suppliers in Europe and Canada. ■

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LATIN AMERICA

Mexico
Brazil
Argentina

Nuclear power took another step forward in Latin America in 1989 as Mexico's first commercial nuclear reactor, Laguna Verde 1, was connected to the grid in April. Operated by Comision Federal de Electricidad, the unit is on schedule to start commercial operation in the first half of 1990. Brazil's Angra 1 began the decade on a favorable note, after overcoming operational difficulties in 1988 and legal challenges in 1989, but Argentina's Atucha 1 was shut down all year for repairs.

In 1989, both Brazil and Argentina elected new presidents, each of whom expressed a desire to further nuclear power development, but continuing hyperinflation and massive foreign debt problems in both countries will likely limit any significant expansion of nuclear power in the near future. Thus, despite some positive signs for the future, the challenges facing Latin America may overwhelm any opportunity for nuclear power to gain significantly during the 1990s.

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ARGENTINA

Argentina has two operating nuclear power units—Atucha 1, a 335-MWe PHWR, which was shut down 17 months for repairs until January 1990. Embalse, a 600-MWe CANDU unit operated well during the year, with an average capacity factor of 89 percent. A third unit, Atucha 2 (692-MWe PHWR), is about 66-percent complete, but financing problems and design changes have pushed back its completion date to 1994.

Atucha 1's poor performance, a severe drought that limited hydropower generation, and extensive downtime for long-neglected maintenance at other electric generation facilities, caused power shortages all year. Electricity rationing became necessary, and five-hour blackouts in alternating zones of Buenos Aires occurred almost daily.

In July, Carlos Menem took office as President of Argentina, pledging the government's recommitment to nuclear fuel cycle self-sufficiency. However, Argentina's severe hyperinflation and economic problems will likely limit Menem's efforts in the foreseeable future.

Argentina has several fuel cycle projects under construction, although little progress was made in 1989:

◆ Expansion of the Pilcaniyeu gaseous diffusion enrichment plant from 40,000 SWU per year to 100,000 SWU per year;

◆ Construction of a 250 tons-per-year heavy water plant at Arroyito (now 93-percent complete);

◆ Construction of a zircaloy fuel fabrication plant at Ezeiza;

◆ Completion of the five tons heavy metal-per-year pilot reprocessing plant at Ezeiza.

All of the projects are scheduled to be completed in 1990; however, the major economic and financial constraints facing Argentina will likely delay the completion timetables.

Argentina reported approximately 12 thousand tons equivalent U_3O_8 in uranium reserves, and has been operating three mines domestically: San Rafael, Los Gigantes, and La Estela. However, the Los Gigantes mine was shut down in December 1989 due to operating inefficiency and a large overestimation of reserves.

Argentina converts concentrates to uranium dioxide at a plant near Cordoba, which has a two-line capacity of 300 tons per year. Conversion to UF_6 and enrichment to 0.85 $^w/_o$ U_{235} occurs at the Pilcaniyeu facility.

Argentina intends to play a leading role in nuclear power development in Latin America and other developing nations. Argentina is developing reactor designs for domestic and export use to complement its ambitious export plans. It also signed an agreement in 1989 with Brazil on cooperation for long-term FBR development. Argentina hopes to build four or five more 700-MWe reactors domestically in the next twenty years as well. Although Argentina has consented to some safeguards on certain nuclear facilities, its continued refusal to sign the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) will limit the availability of external technical expertise and much-needed resources.

Table 26
NUCLEAR POWER UNITS IN ARGENTINA

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Atucha 1	CNEA[3]	335	HWR	1974	0	0
Atucha 2	CNEA	692	HWR	1994	—	—
Embalse	CNEA	600	HWR	1984	89	5,039

[1] COD = Commercial Operation Date (actual or expected)
[2] Source: *Nucleonics Week*
[3] CNEA = Comision Nacional de Energia Atomica

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BRAZIL

Brazil's only operating reactor, Angra 1 (626-MWe PWR), was shut down for refueling in October. A court order obtained by members of Brazil's Green Party had prevented its scheduled restart in December. However, a successful appeal, based upon a favorable review from a recent IAEA Operational Safety Review Team (OSART), overturned the court order, and Angra 1 restarted in January 1990. Angra 2 and 3, both 1245-MWe PWRs, are under construction and scheduled for completion this decade (**Table 27**).

Elected President of Brazil in December, Fernando Collor supports nuclear power. However, the country's severe economic crisis (inflation is running at more than 1,200 percent per year), will hamper development of its nuclear industry in the near term. Brazil has not signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), but does have agreements to submit all of its commercial reactors to IAEA safeguards. Additionally, Brazil and Argentina (also a non-signatory to the NPT) have renewed cooperation efforts on nuclear development. This cooperation has led to several visits to each other's fuel cycle facilities, as well as the approval of official cooperation agreements.

The Brazilian Nuclear Energy Council continues to enforce rules that limit exports of natural uranium concentrates to 20 percent of each mine's output. This makes uranium mining in Brazil much less attractive to foreign investment. Brazil produced about 130 thousand pounds equivalent U_3O_8 in 1989 at its Pocos de Caldas mine, and is likely to produce at about the same level in 1990.

Table 27
NUCLEAR POWER UNITS IN BRAZIL

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Angra 1	Furnas[3]	626	PWR	1984	28	0
Angra 2	Furnas	1,229	PWR	1994	—	—
Angra 3	Furnas	1,229	PWR	1997	—	—

[1] COD=Commercial Operation Date (actual or expected)
[2] Source: *Nucleonics Week*
[3] Furnas Centrais Electricas SA

MEXICO

Laguna Verde 1, Mexico's first commercial nuclear power unit, was connected to the power grid on April 13, 1989. Expected to enter commercial operation in the first half of 1990, it will make Mexico the 27th country to utilize nuclear power. Comision Federal de Electricidad began construction on the $3.5 billion Laguna Verde 1 plant in 1973; it first reached criticality on November 8, 1988.

Laguna Verde 2 is the second 654-MWe GE BWR-5 planned for the site. It is more than 60% complete, and planned for commercial operation in 1993 or 1994. When both reactors are in commercial operation, they will account for about five percent of Mexico's installed capacity and should provide 7-8 percent of annual electrical generation.

Mexico has over ten thousand tons of reasonably assured uranium resources, but needs capital to develop these deposits. Financial constraints limit Mexico's uranium contracting options as well. Additionally, the lack of bilateral safeguards agreements prevents Mexico from purchasing uranium from South Africa, Canada, or Australia. Despite these limitations, Mexico signed a supply contract with a US producer in 1989 for three reloads for the Laguna Verde 1 plant. ■

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NORTH AMERICA

North America, which essentially became a single market on January 1, 1989, via the US/Canada Free Trade Agreement, produced less uranium in 1989 and nuclear power growth was limited. Falling uranium prices prompted a number of US and Canadian uranium producers to either reduce output or completely shut down operations. Some of these and other producers became active buyers rather than sellers in the spot market, preferring to purchase rather than produce for a portion of their delivery commitments.

North America remained the world's largest uranium producing region, accounting for approximately 48 percent of 1989 output. North America added 2,350 MW of nuclear electricity generating capacity in 1989, as two US reactors entered commercial operation.

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CANADA

Uranium Production and Exploration

Although uranium output declined during 1989, Canada maintained its position as the market's leading uranium producing country. Canada produced about 29 million pounds equivalent U_3O_8, a decline of more than nine percent from the 1988 level of about 32 million pounds (**Table 28**).

Saskatchewan

Saskatchewan production suffered the largest decrease in 1989, falling from 21.2 million pounds equivalent U_3O_8 to 19.3 million pounds. Key Lake, owned 66.67 percent by Cameco and 33.33 percent by Uranerz Exploration and Mining, increased its production rate to 12.7 million pounds equivalent U_3O_8. The Deilmann pit (**Figure 27**) provided the majority of millfeed, which was supplemented with low-grade ore from the Gaertner pit. The Gaertner pit

Table 28
CANADAN URANIUM PRODUCTION (1986-1989)

Mine	Ownership	Production (Thousand Pounds Equivalent U_3O_8)				1989 Relative To 1988
		1986	1987	1988	1989	
Ontario:						
Elliot Lake	Denison Mines Limited	5,239	4,703	5,054	4,446	-12.0%
Panel	Rio Algom Ltd.	2,303	2,145	1,999	1,700	-15.0%
Quirke	Rio Algom Ltd.	3,273	2,896	2,891	2,750	-4.9%
Stanleigh	Rio Algom Ltd.	1,737	1,219	1,217	1,200	-1.4%
Saskatchewan:						
Cluff Lake	Amok Ltd. (80%) Cameco[1] (20%)	2,167	2,154	2,235	1,890	-15.4%
Key Lake	Cameco[1] (67%) Uranerz (33%)	12,586	13,517	12,033	12,720	+5.7%
Rabbit Lake/Collins Bay	Cameco[1]	3,190	5,709	6,965	4,670	-33.0%
Total		**30,495**	**32,343**	**32,394**	**29,376**	**–9.3%**

[1] Formerly Eldorado Resources Limited and Saskatchewan Mining Development Corporation (SMDC).

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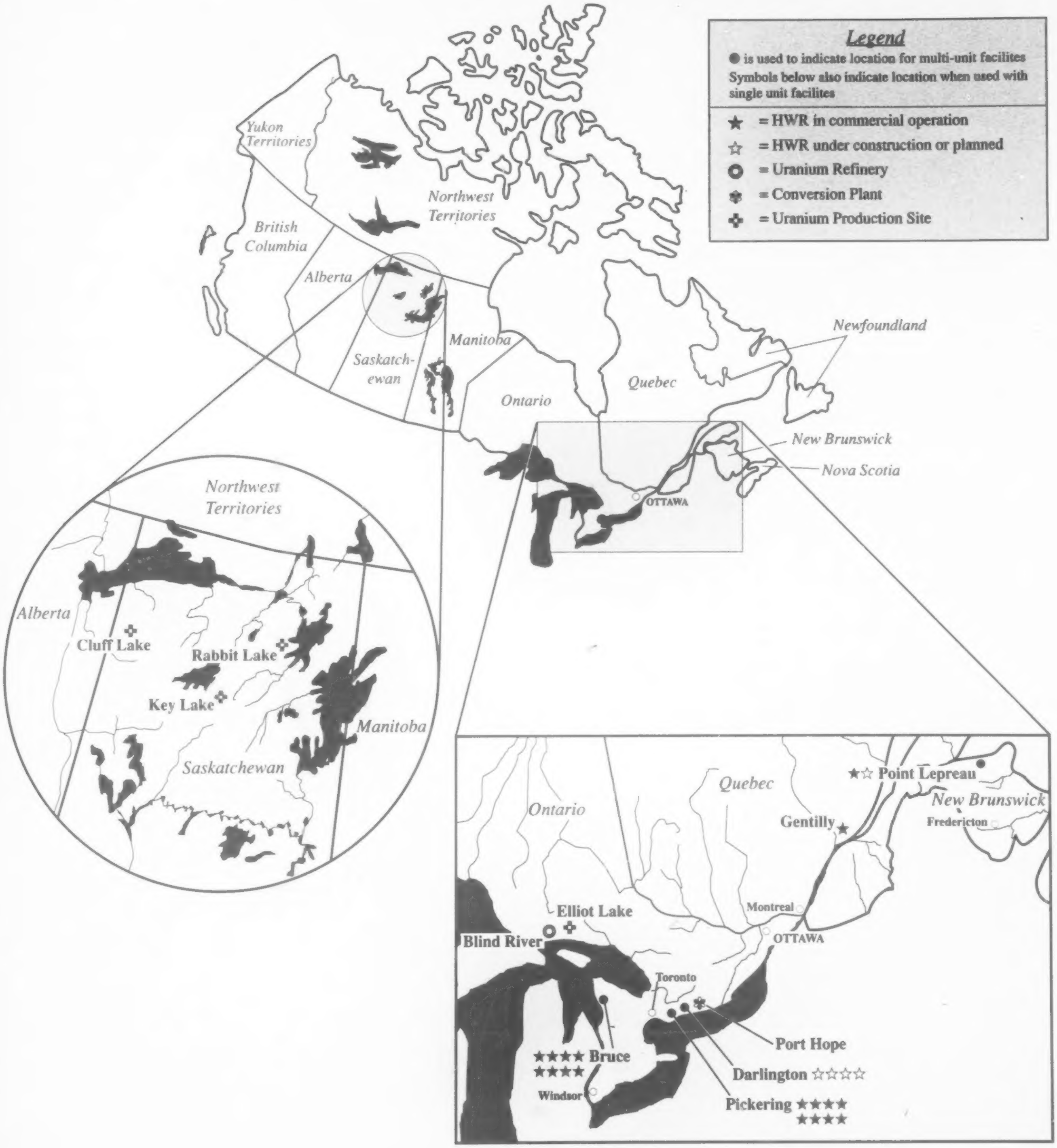
Figure 26
CANADA
NUCLEAR POWER UNITS, FUEL CYCLE FACILITIES
AND URANIUM PRODUCTION AREAS


Legend
● is used to indicate location for multi-unit facilites
Symbols below also indicate location when used with single unit facilites
★ = HWR in commercial operation
☆ = HWR under construction or planned
○ = Uranium Refinery
✽ = Conversion Plant
✚ = Uranium Production Site
Yukon Territories
Northwest Territories
British Columbia
Alberta
Saskatch-ewan
Manitoba
Ontario
Quebec
Newfoundland
New Brunswick
Nova Scotia
OTTAWA
Northwest Territories
Alberta
Cluff Lake
Rabbit Lake
Key Lake
Manitoba
Saskatchewan
Quebec
Ontario
★☆ Point Lepreau
New Brunswick
Fredericton
Gentilly ★
Montreal
Elliot Lake
Blind River
OTTAWA
Toronto
Port Hope
★★★★ Bruce ★★★★
Darlington ☆☆☆☆
Windsor
Pickering ★★★★ ★★★★

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is being decommissioned, but stockpiled ore was available during 1989. A molybdenum recovery circuit was installed in 1989 in order to process the Deilmann pit ores.

Cameco acquired full ownership of the Rabbit Lake Mill, as well as several associated ore bodies, following the merger of Saskatchewan Mining and Development Corp. (SMDC) and Eldorado Resources. (In April 1990, Cameco announced it was selling one-third of its interest in Rabbit Lake to Uranerz.) Previous plans called for sequential development of the Collins Bay A zone and Collins Bay D zone after the depletion of the Collins Bay B zone, which has been providing millfeed.

Following a review of Rabbit Lake operations and development plans, the owners decided to modify the mining sequence and commence development of the Eagle Point ore bodies. This operational change will result in lower production costs than would have been the case with Collins Bay A and D development, since the similarity between the old Rabbit Lake mine and the Eagle Point ore reserves eliminates the need for mill modifications that would have been necessary to accommodate the Collins Bay A and D ore.

Cameco made several modifications to the Rabbit Lake mill during 1989, increasing the nominal annual production capacity to 12 million pounds equivalent U_3O_8. The Rabbit Lake mine was shut down effective July 1, 1989, for a minimum of six months in order to reduce Cameco's uranium inventories. Rabbit Lake produced approximately 4.7 million pounds for the year, a decrease of almost 2.3 million pounds from 1988.

Cluff Lake, owned 80 percent by AMOK Ltd. and 20 percent by Cameco, produced 1.9 million pounds equivalent U_3O_8 in 1989, compared to more than 2.2 million pounds the previous year. The Claude open pit was depleted during 1989, and underground mining of the Dominique-Peter underground mine resumed in April 1989. Moreover, AMOK accelerated stripping of the Dominique-Janine open pit at mid-year. In July, AMOK announced an extended shutdown of the Cluff Lake mill until early 1990.

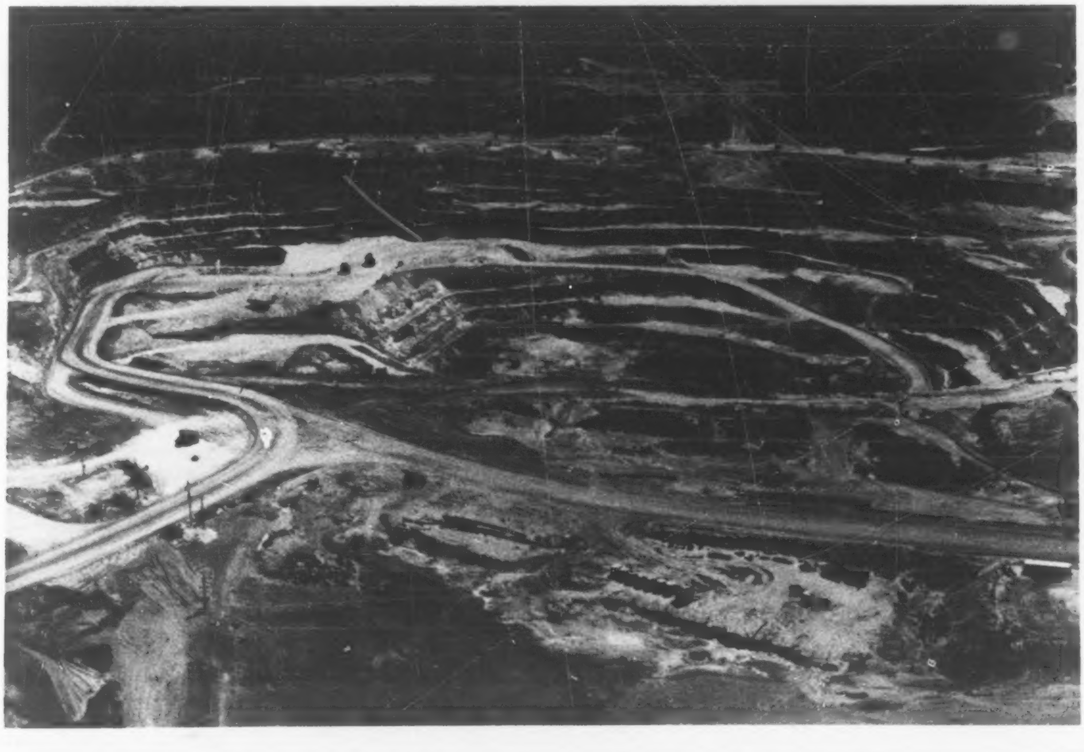

Figure 27. The Deilmann pit at Key Lake. *(Photo courtesy of Cameco)*

NORTH AMERICA

Elliot Lake

Production rates decreased at both of the Elliot Lake uranium producers (Denison Mines Ltd. and Rio Algom Ltd.) during 1989. Primary uranium production within the Elliot Lake region totalled 10.1 million pounds equivalent U_3O_8 in 1989, down from 11.2 million pounds the previous year.

Denison Mines Ltd. produced over 4.4 million pounds equivalent U_3O_8, ten percent less than its 5.1 million pound output in 1988. In 1990, the company announced that annual production would be reduced from 4.3 to 2.7 million pounds equivalent U_3O_8 at its Elliot Lake mine.

In February 1989, Denison announced that the company intended to sell all or a portion of its oil and gas holdings and develop uranium as its core business, based principally on the Midwest Joint Venture (Saskatchewan), Koongarra property (Northern Territories, Australia), and possible acquisitions in the USA.

Rio Algom Ltd. continued to operate its three mine and mill complexes in the Elliot Lake region. Total uranium production approximated 5.7 million pounds equivalent U_3O_8, down eight percent from 1988 (6.1 million pounds equivalent U_3O_8). The Panel Mine suffered the largest decline in percentage terms (19 percent) as well as volume, down to 1.7 million pounds equivalent U_3O_8 from 2.1 million pounds.

On January 26, 1990, Rio Algom Ltd. announced that it was making a special one-time provision of C$85 million against pre-tax 1989 earnings to "fully cover estimated costs of the eventual shutdown of its uranium mines in Elliot Lake, Ontario." The company anticipates that the Quirke and Panel mines will be shut down in early 1991. Until that time, the mines are expected to produce at current levels. Production from the Stanleigh mine will be used to fulfill delivery commitments to Ontario Hydro.

Canadian uranium exploration activities centered upon high-grade discoveries in Saskatchewan and the Northwest Territories. Shaft sinking progressed at the Cigar Lake Project, principally owned by Cameco (48.75 percent) and Cogema Canada, Ltd. (32.625 percent). The two-year C$50 million program includes completing the shaft down to 500 meters (scheduled for April 1990) and conducting sufficient technical evaluation to allow for a thorough project feasibility study. The Cigar Lake deposit represents the largest high-grade uranium reserve in the world. Drilling has identified reserves of 285 million pounds averaging 14 percent equivalent U_3O_8 in the main pod, and an additional 100 million pounds (averaging 4.5 percent U_3O_8) in the Western Extension (**Table 29**).

Denison Mines Ltd. reported notable progress at the Midwest Joint Venture, owned by Denison (45 percent), Uranerz Exploration & Mining (20 percent), Bow Valley Industries Ltd. (20 percent), and PNC Exploration (Canada) Co. Ltd. (15 percent). An eighteen-month underground evaluation and test operation was concluded in 1989 at a cost of C$17.5 million. An exploration shaft was sunk to a depth of 185 meters, and an excavation (crosscut) was completed above the ore body. Test mining was conducted utilizing blind-hole boring. Denison anticipates that a project feasibility study will be completed prior to mid-1990 and a development decision made by the end of the third quarter.

Urangesellschaft Canada Ltd.'s proposed uranium mine-mill complex, Kiggavik, located near Baker Lake in the Northwest Territories, made additional progress during 1989. An environmental assessment of the project was filed in late January 1990 with the Federal Environmental Assessment Review Office. The operator has proposed to develop two open-pit mines over an eleven-year period. Nominal annual production would be 3.5 million pounds equivalent U_3O_8 (average ore grade of 0.48 percent U_3O_8). CEGB Exploration (Canada) Ltd. purchased a 20-percent equity share in the project, joining Urangesellschaft Canada Ltd. (79 percent) and Daewoo Corporation (one percent).

Energy, Mines and Resources Canada (EM&R) released its latest data regarding uranium resources and future requirements in late 1989. Estimates at January 1, 1989, show that Canada's uranium resource endowment totaled 544,000 MTU (1.4 billion pounds equivalent U_3O_8). This represents a decrease of more than four percentage points from the two previous years.

Uranium exploration expenditures rose significantly from 1987 (C$37 million) to 1988 (C$59 million). As reported by EM&R, combined exploration and surface development drilling approximated 164,000 meters in 1987, but increased to 202,000 meters the following year. More than 85 percent of that drilling was conducted in Saskatchewan.

Canadian uranium producers are committed to export about 144 MTU (376 million pounds U_3O_8) under sales agreements reviewed and accepted by the Canadian government as of January 1, 1989 (**Table 30**). Delivery commitments to the USA exceeded 40 percent of that total, while future deliveries to Japan represented 17.5 percent of the aggregate.

Table 29
UNDEVELOPED CANADIAN URANIUM DEPOSITS
(Scheduled for production before 2000)

Deposit	Location	Ownership	Reserves (Million Pounds Equivalent U_3O_8)
Cigar Lake	Saskatchewan	Cameco (48.75%) Cogema (36.375%) Idemitsu Kosan (12.875%) KEPCO[1] (2.00%)	385
Dawn Lake	Saskatchewan	Cameco (50.486%) Cogema (19.525%) PNC[2] (17.989%) CEGB[3] (7.5%) KEPCO[1] (4.5%)	30
Kiggavik	Northwest Territories	UG[4] (79.0%) Daewoo [Korea] (1.0%) CEGB[3] (20.0%)	40
McClean Lake	Saskatchewan	Occidental (33.3%) Inco (33.3%) Minatco[5] (33.3%)	14
Midwest	Saskatchewan	Denison (45.0%) Bow Valley (20.0%) Uranerz (20.0%) PNC[2] (15.0%)	56

[1] KEPCO = Korea Electric Power Corporation. KEPCO purchased a two-percent non-voting interest in Cigar Lake.

[2] PNC = PNC (Exploration) Canada Limited, a wholly-owned subsidiary of Power Reactor and Nuclear Fuel Development Corporation (Japan).

[3] CEGB = Central Electricity Generating Board (United Kingdom).

[4] UG = Urangesellschaft Canada Limited, a wholly-owned subsidiary of Urangesellschaft mbH (West Germany).

[5] Minatco = Minatco Limited, a wholly-owned subsidiary of Total Compagnie Minière (France).

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NORTH AMERICA

Table 30
CANADIAN URANIUM UNDER EXPORT CONTRACT[1]

Country of Buyer[2]	MTU
Belgium	3,325
Finland	3,512
France	9,715
Italy	1,115
Japan	25,046
South Korea	6,903
Spain	3,559
Sweden	8,977
Switzerland	154
United Kingdom	8,293
United States	57,718
West Germany	15,126
Total	**143,443**

Source: Uranium in Canada: 1989 Assessment of Supply and Requirements, The Minister of Energy, Mines and Resources Canada, 1989, Ottawa, Ontario.

[1] The amount of uranium specified in all export contracts reviewed and accepted under Canada's uranium export policy since September 5, 1974. The country totals are adjusted to reflect new and amended contracts as of January 1, 1989.

[2] In most cases, indicates country of end-user.

Nuclear Power Developments

Several 1989 events in the Canadian nuclear power arena might lead to more encouraging times in the future. Ontario Hydro released its long-awaited electricity supply and demand study, which indicates that more nuclear units could be ordered in the near future.

Engineering design work continued on the CANDU 3 reactor, incorporating standardized design and off-site fabrication. Lastly, limited progress was reported on the "Local Energy System" project which utilizes the SLOWPOKE reactor concept.

Ontario Hydro

Ontario Hydro released its latest electricity demand and supply plan, "Providing the Balance of Power—Ontario Hydro's Plan to Serve Customers' Electricity Needs," for public and governmental review and comment. This effort emerged from an options study conducted during 1984–1989. The current plan assesses electricity needs through the year 2014 and examined a total of 26 separate supply options.

The preferred option (Case 15) envisions the construction of ten CANDU reactors (881 MWe each) at three stations by the year 2014. These units are required to meet the median long-term load forecast of energy growth in the Ontario Hydro system, which is 2.3 percent per year for the period 1987-2014. Hearings before the Federal Environmental Assessment Board are planned to begin in September 1990.

Construction of the Darlington Station (four 881-MWe CANDU 6 reactors) continues. Darlington 2 went critical in November, and received its Atomic Energy Control Board (AECB) operating license in February 1990. The remaining Darlington units are scheduled for commercial operation in December of 1990, 1991 and 1992, at which time the Darlington Project will be complete (**Table 31**).

The retubing program of the Pickering units continued. Pickering 3 is expected to re-enter operation in May, 1991, while Pickering 4 will be taken out of service in March 1991.

CANDU 3

Atomic Energy Canada Ltd. (AECL) reported that the engineering design work on the CANDU 3 reactor (450 MWe, standardized design) was approximately 50-percent complete. The CANDU 3 reactor's basic design has been taken from the CANDU 6, and is being further refined.

AECL sees this concept being applicable not only to Canadian utilities (initial CANDU 3 is a possible candidate for New Brunswick Power system by 1996), but also utilities in East European countries, the Far East, and the USA. AECL hopes to receive NRC design certification by the mid-1990s in order to allow US utilities to seriously consider the CANDU 3 for post-2000 electric generation requirements.

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Table 31
NUCLEAR POWER UNITS IN CANADA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Bruce 1	Ontario Hydro	769	HWR	1977	69	5,483
Bruce 2	Ontario Hydro	769	HWR	1977	18	1,422
Bruce 3	Ontario Hydro	769	HWR	1978	55	4,318
Bruce 4	Ontario Hydro	769	HWR	1979	76	5,990
Bruce 5	Ontario Hydro	860	HWR	1985	95	7,607
Bruce 6	Ontario Hydro	837	HWR	1984	74	5,753
Bruce 7	Ontario Hydro	837	HWR	1986	97	7,766
Bruce 8	Ontario Hydro	837	HWR	1987	90	6,986
Gentilly 2	Hydro Quebec	640	HWR	1983	86	5,180
Pickering 1	Ontario Hydro	515	HWR	1971	72	3,409
Pickering 2	Ontario Hydro	515	HWR	1971	75	3,556
Pickering 3	Ontario Hydro	515	HWR	1972	38	1,793
Pickering 4	Ontario Hydro	515	HWR	1973	51	2,410
Pickering 5	Ontario Hydro	515	HWR	1983	76	3,601
Pickering 6	Ontario Hydro	515	HWR	1984	88	4,170
Pickering 7	Ontario Hydro	515	HWR	1985	76	3,604
Pickering 8	Ontario Hydro	515	HWR	1986	96	4,537
Point Lepreau 1	New Brunswick EPC[3]	630	HWR	1983	95	5,648
Total		11,837		*(1989 Average:*	74)[4]	83,233

Units Under Construction or Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[5]
Darlington 1	Ontario Hydro	881	HWR	1990	96
Darlington 2	Ontario Hydro	881	HWR	1990	99
Darlington 3	Ontario Hydro	881	HWR	1991	75
Darlington 4	Ontario Hydro	881	HWR	1992	50
Point Lepreau 2	New Brunswick EPC[3]	900	HWR	Indefinite	0
Total		4,424			

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[1] COD = Commercial Operation Date (actual or expected)

[2] Source: *Nucleonics Week*

[3] EPC = Electric Power Company

[4] Average does not include those units which entered commercial operation or were retired during 1989.

[5] Source: *Nuclear News*

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Local Energy Systems

AECL is also promoting a concept called "Local Energy Systems." Specifically, the SLOWPOKE reactor would be utilized for district heating. Utilizing in-pool heat exchangers, the SLOWPOKE would provide water at 85 degrees C for industrial uses.

In 1988, AECL made the commitment to develop a LES based upon a 10-MWe reactor design which could be upgraded to 15 MWe. One option under study is the production of electricity in addition to the heated water.

One proposed demonstration project would involve the installation of a SLOWPOKE at the University of Saskatchewan. A site assessment and environmental review are in progress. The LES project would provide as much as 27 percent of the heat requirements for the university and could be in operation by 1994.

US/Canada Free Trade Agreement (FTA)

The US/Canada Free Trade Agreement (FTA) took effect on January 1, 1989. Two provisions are especially important to the nuclear industry.

First, the agreement provides that Canadian-origin uranium concentrates shall be exempt from any restrictions which might be enacted under Section 161(v) of the Atomic Energy Act of 1954, as amended. This language effectively precluded the US uranium production industry from pursuing restrictions on the provision of USDOE enrichment services for foreign-origin uranium.

Secondly, the FTA exempts the USA from the requirements of Canada's uranium further processing (upgrading) policy. In a letter dated December 30, 1988, The Honorable Marcel Messe, Canadian Minister of Energy, Mines and Resources, set forth additional clarification of this provision.

Under the FTA, the Canadian government will grant an exemption from the further processing policy for a particular export contract if uranium is to be refined and converted in the USA and ultimately consumed in a US reactor. In addition, under the concept of significant transformation, such concentrates shall be exempted from further processing in Canada if the Canadian concentrates are to be refined, converted, and enriched in the USA prior to export to a third country. Therefore, for example, if a Japanese utility purchased Canadian-origin concentrates and then contracted to have that material converted and enriched in the US for export to Japan, an exemption from the Canadian upgrade policy would be granted.

USA

Overview

The year 1989 ended a decade in which the US nuclear power industry underwent substantial changes, some for the better, but most for the worst. Some of the 1989 developments will illustrate.

◆ Residents of Sacramento, California voted to shut down the city's 15-year-old Rancho Seco nuclear unit. This was the first such victory for opponents of nuclear power, after 14 unsuccessful referenda in 13 years.

◆ Public Service Company of Colorado voluntarily shut down its Fort St. Vrain HTGR, the only one of its type ever built for power production in the USA. After 15 years of struggle, the utility succumbed to persistent operational problems and decided to dismantle the unit.

◆ The Shoreham unit was sold to the State of New York for $1, on the condition that it never operate, marking the first time a completed US nuclear plant has been barred from operating.

◆ On the other hand, the backlog of nuclear units under construction, which was a costly problem throughout the 1980s, has been effectively reduced to only a handful of units.

◆ Nuclear power's proponents took some small comfort from the fact that the Seabrook reactor in New Hampshire, the subject of furious controversy over whether it should be allowed to operate after its completion, received clearance for low-power testing. Public Service of New Hampshire, the unit's operator, received a full-power operating license on March 1, 1990, and expects to reach full-power operation in the first half of 1990.

Few positive developments took place in the US uranium production sector, which suffered further contraction and consolidation during 1989. The state of New Mexico, which in 1978 produced 17 million pounds equivalent U_3O_8, only produced about 2.3 million pounds in 1989, and will produce only about 400 thousand pounds in 1990. The last active mine in New Mexico, Chevron's Mt. Taylor, was reduced to standby status in early 1990. In other areas of the US industry, however, the negative public attitudes toward nuclear power began to show signs of change. Constituents' concern for the environment caused politicians to consider legislation to mitigate the greenhouse effect and acid rain, leading many environmentalists, some who had been strongly antinuclear, to recommend a reconsideration of nuclear power as a clean source of energy. If this trend continues, the US nuclear power industry might be revived in the late 1990s, but any resultant increases in uranium demand would be delayed into the next century.

Unfortunately, while public attitudes toward nuclear power are changing, risks associated with building nuclear plants continue to deter utilities from placing orders. US vendors such as General Electric and Westinghouse are working on new designs for smaller, modular units (around 600 MWe) in an effort to build more cost-effective units than the larger plants. The smaller units will also incorporate passively, inherently safe designs in an effort to win public acceptance. In addition, the industry continues to work toward higher capacity factors by extending cycle lengths and reducing the length of maintenance outages.

A major impediment to the resurgence of the industry, however, is the lack of a high-level nuclear waste storage facility. During 1989, DOE made little progress evaluating the Yucca Mountain, Nevada site, and the deadline for putting a repository in place was actually extended seven years to 2010. This remains a highly charged political issue, as the Nevada State Government filed suit to block site characterization.

Until this issue is resolved, intervenors will have a strong argument for opposing the construction of needed additions to nuclear capacity. Delays in solving the high-level waste issue will be particularly costly to the Northeast, where nuclear power opposition remains high, despite an impending shortfall of electric generating capacity and a severe dependence on oil imports.

Nuclear Power Developments

Two units entered commercial operation during 1989—Houston Lighting and Power's South Texas Unit 2, a 1,250-MWe PWR, and Georgia Power's Vogtle Unit 2, a 1,100-MWe PWR (**Table 32**). In addition, Philadelphia

Table 32
NUCLEAR POWER UNITS IN THE USA

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Arkansas 1	Entergy Operations	836	PWR	1974	45	3,593
Arkansas 2	Entergy Operations	858	PWR	1980	70	5,748
Arnold 1	Iowa Electric Light & Power Co.	515	BWR	1975	69	3,403
Beaver Valley 1	CAPCO[3]	810	PWR	1976	52	4,076
Beaver Valley 2	CAPCO	833	PWR	1987	62	4,836
Big Rock Point	Consumers Power Co.	67	BWR	1963	67	440
Braidwood 1	Commonwealth Edison Co.	1,120	PWR	1988	48	4,891
Braidwood 2	Commonwealth Edison Co.	1,120	PWR	1988	73	7,471
Browns Ferry 1	Tennessee Valley Authority	1,065	BWR	1974	0	0
Browns Ferry 2	Tennessee Valley Authority	1,065	BWR	1975	0	0
Browns Ferry 3	Tennessee Valley Authority	1,065	BWR	1977	0	0
Brunswick 1	Carolina Power & Light Co.	790	BWR	1977	58	4,331
Brunswick 2	Carolina Power & Light Co.	790	BWR	1975	58	4,349
Byron 1	Commonwealth Edison Co.	1,105	PWR	1985	92	9,432
Byron 2	Commonwealth Edison Co.	1,105	PWR	1987	63	6,447
Callaway	Union Electric Co.	1,120	PWR	1984	84	8,762
Calvert Cliffs 1	Baltimore Gas & Electric Co.	825	PWR	1975	18	1,410
Calvert Cliffs 2	Baltimore Gas & Electric Co.	825	PWR	1977	20	1,512
Catawba 1	Duke Power Co.	1,129	PWR	1985	78	8,258
Catawba 2	Duke Power Co.	1,129	PWR	1986	66	6,928
Clinton 1	Illinois Power Co.	930	BWR	1987	35	3,051
Cook 1	American Electric Power Co.	1,020	PWR	1975	59	5,654
Cook 2	American Electric Power Co.	1,060	PWR	1978	70	6,900
Cooper	Nebraska Public Power District	764	BWR	1974	70	4,943
Crystal River 3	Florida Power Corp.	821	PWR	1977	41	3,090
Davis-Besse 1	CAPCO	860	PWR	1978	95	7,709
Diablo Canyon 1	Pacific Gas & Electric Co.	1,073	PWR	1985	76	7,591
Diablo Canyon 2	Pacific Gas & Electric Co.	1,087	PWR	1986	89	9,045
Dresden 2	Commonwealth Edison Co.	772	BWR	1970	68	4,984
Dresden 3	Commonwealth Edison Co.	773	BWR	1971	74	5,374

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] CAPCO = Central Area Power Coordinating Group

Table 32
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Farley 1	Southern Company Services	813	PWR	1977	83	6,358
Farley 2	Southern Company Services	823	PWR	1981	78	5,931
Fermi 2	Detroit Edison Co.	1,093	BWR	1988	51	5,466
Fitzpatrick	New York Power Authority	778	BWR	1975	84	6,274
Fort Calhoun 1	Omaha Public Power District	478	PWR	1974	79	3,465
Ginna 1	Rochester Gas & Electric Corp.	470	PWR	1970	74	3,234
Grand Gulf 1	Entergy Operations	1,142	BWR	1985	71	8,169
Haddam Neck	Northeast Utilities	565	PWR	1968	58	3,122
Harris 1	Carolina Power & Light Co.	860	PWR	1987	72	6,050
Hatch 1	Southern Company Services	756	BWR	1975	96	6,770
Hatch 2	Southern Company Services	768	BWR	1979	61	4,365
Hope Creek 1	Public Service Electric & Gas	1,067	BWR	1986	71	6,930
Indian Point 2	Consolidated Edison Co. New York	864	PWR	1974	52	4,664
Indian Point 3	New York Power Authority	965	PWR	1976	57	5,052
Kewaunee	Wisconsin Public Service Corp.	503	PWR	1974	80	3,934
La Salle 1	Commonwealth Edison Co.	1,036	BWR	1984	65	6,420
La Salle 2	Commonwealth Edison Co.	1,036	BWR	1984	69	6,748
Limerick 1	Philadelphia Electric Co.	1,055	BWR	1986	55	5,505
Limerick 2	Philadelphia Electric Co.	1,055	BWR	1990	—	1,117
McGuire 1	Duke Power Co.	1,129	PWR	1981	76	8,129
McGuire 2	Duke Power Co.	1,129	PWR	1984	72	7,729
Millstone 1	Northeast Utilities	654	BWR	1971	80	4,858
Millstone 2	Northeast Utilities	863	PWR	1975	65	5,089
Millstone 3	Northeast Utilities	1,142	PWR	1986	70	7,423
Monticello	Northern States Power Co.	536	BWR	1971	55	2,787
Nine Mile Point 1	Niagara Mohawk Power Corp.	610	BWR	1969	0	0
Nine Mile Point 2	Niagara Mohawk Power Corp.	1,045	BWR	1988	45	4,621
North Anna 1	Virginia Electric Power Co.	915	PWR	1978	55	4,532
North Anna 2	Virginia Electric Power Co.	915	PWR	1980	75	6,214

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

Table 32
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
Oconee 1	Duke Power Co.	846	PWR	1973	78	6,242
Oconee 2	Duke Power Co.	846	PWR	1974	79	6,300
Oconee 3	Duke Power Co.	846	PWR	1974	83	6,630
Oyster Creek 1	GPU Nuclear Corp.	620	BWR	1969	43	2,537
Palisades	Consumers Power Co.	730	PWR	1971	52	3,879
Palo Verde 1	Arizona Public Service Co.	1,221	PWR	1986	17	1,934
Palo Verde 2	Arizona Public Service Co.	1,221	PWR	1986	45	5,101
Palo Verde 3	Arizona Public Service Co.	1,221	PWR	1988	12	1,421
Peach Bottom 2	Philadelphia Electric Co.	1,051	BWR	1974	42	4,041
Peach Bottom 3	Philadelphia Electric Co.	1,035	BWR	1974	3	261
Perry 1	CAPCO[3]	1,205	BWR	1987	51	5,626
Pilgrim 1	Boston Edison Co.	670	BWR	1972	30	1,792
Point Beach 1	Wisconsin Electric Power Co.	485	PWR	1970	82	3,775
Point Beach 2	Wisconsin Electric Power Co.	485	PWR	1972	80	3,652
Prairie Island 1	Northern States Power Co.	503	PWR	1973	95	4,658
Prairie Island 2	Northern States Power Co.	500	PWR	1974	84	4,119
Quad Cities 1	Commonwealth Edison Co.	769	BWR	1973	61	4,476
Quad Cities 2	Commonwealth Edison Co.	769	BWR	1973	82	6,006
River Bend 1	Gulf States Utilities Co.	936	BWR	1986	59	5,121
Robinson 2	Carolina Power & Light Co.	665	PWR	1971	46	2,949
Salem 1	Public Service Electric & Gas	1,106	PWR	1977	65	6,514
Salem 2	Public Service Electric & Gas	1,106	PWR	1981	80	8,101
San Onofre 1	Southern California Edison Co.	436	PWR	1968	32	1,268
San Onofre 2	Southern California Edison Co.	1,070	PWR	1983	56	5,541
San Onofre 3	Southern California Edison Co.	1,080	PWR	1984	94	9,317
Seabrook	Yankee Atomic Group[4]	1,150	PWR	1990	—	—
Sequoyah 1	Tennesse Valley Authority	1,148	PWR	1981	96	9,898
Sequoyah 2	Tennesse Valley Authority	1,148	PWR	1982	61	6,332
South Texas 1	Houston Lighting & Power Co.	1,250	PWR	1988	57	6,576
South Texas 2	Houston Lighting & Power Co.	1,250	PWR	1989	—	3,976

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] CAPCO = Central Area Power Coordinating Group

[4] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

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Table 32
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1989 Capacity Factor (percent)[2]	Total 1989 Electricity Generation (GWh)[2]
St. Lucie 1	Florida Power & Light Co.	839	PWR	1976	96	7,324
St. Lucie 2	Florida Power & Light Co.	839	PWR	1983	74	5,755
Summer	South Carolina Electric & Gas	885	PWR	1984	68	5,715
Surry 1	Virginia Electric Power Co.	781	PWR	1972	46	3,342
Surry 2	Virginia Electric Power Co.	781	PWR	1973	13	944
Susquehanna 1	Pennsylvania Power & Light Co.	1,032	BWR	1983	62	5,931
Susquehanna 2	Pennsylvania Power & Light Co.	1,038	BWR	1985	83	7,844
Three Mile Island 1	GPU Nuclear Corp.	808	PWR	1974	100	7,632
Trojan	Portland General Electric Co.	1,095	PWR	1976	57	5,841
Turkey Point 3	Florida Power & Light Co.	666	PWR	1972	60	3,798
Turkey Point 4	Florida Power & Light Co.	666	PWR	1973	35	2,245
Vogtle 1	Southern Company Services	1,079	PWR	1987	90	9,162
Vogtle 2	Southern Company Services	1,100	PWR	1989	—	6,258
Waterford 3	Entergy Operations	1,075	PWR	1985	79	7,970
WNP 2	WPPSS[3]	1,095	BWR	1984	63	6,370
Wolf Creek	Kansas Gas & Electric Co.	1,128	PWR	1985	97	10,110
Yankee Maine	Yankee Atomic Group[4]	810	PWR	1972	95	7,176
Yankee Rowe	Yankee Atomic Group	167	PWR	1961	86	1,396
Yankee Vermont	Yankee Atomic Group	504	BWR	1972	80	3,792
Zion 1	Commonwealth Edison Co.	1,040	PWR	1973	55	5,225
Zion 2	Commonwealth Edison Co.	1,040	PWR	1974	85	8,039
Total		**98,233**		**(1989 Average:**	**62)**[5]	**555,096**

[1] COD = Commercial Operation Date

[2] Source: *Nucleonics Week*

[3] Washington Public Power Supply System

[4] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

[5] Average does not include those units which entered commercial operation or were retired during 1989.

NUEXCO

NORTH AMERICA

INDEX TO FIGURE 28
LICENSED NUCLEAR POWER STATIONS IN THE USA

FUEL BUYER	STATION	
1 - Yankee Atomic Group[1]	Yankee Maine	■
2 - Yankee Atomic Group[1]	Seabrook	■
3 - Yankee Atomic Group[1]	Yankee Vermont	▲
4 - Yankee Atomic Group[1]	Yankee Rowe	■
5 - Yankee Atomic Group[1]	Haddam Neck	■
6 - Boston Edison Co.	Pilgrim	▲
7 - Northeast Utilities	Millstone	▲■■
8 - Long Island Lighting Co.	Shoreham	△
9 - Consolidated Edison Co. New York	Indian Point 2	■
New York Power Authority	Indian Point 3	■
10 - New York Power Authority	Fitzpatrick	▲
11 - Niagara Mohawk Power Corp.	Nine Mile Point	▲▲
12 - Rochester Gas and Electric Corp.	Ginna	■
13 - Pennsylvania Power and Light Co.	Susquehanna	▲▲
14 - Philadelphia Electric Co.	Limerick	▲▲
15 - Philadelphia Electric Co.	Peach Bottom	▲▲
16 - GPU Nuclear Corp.	Three Mile Island	■
17 - GPU Nuclear Corp.	Oyster Creek	▲
18 - Public Service Electric & Gas	Salem	■■
19 - Public Service Electric & Gas	Hope Creek	▲
20 - Baltimore Gas & Electric Co.	Calvert Cliffs	■■
21 - Virginia Electric Power Co.	North Anna	■■
22 - Virginia Electric Power Co.	Surry	■■
23 - Carolina Power & Light Co.	Harris	■
24 - Carolina Power & Light Co.	Brunswick	▲▲
25 - Carolina Power & Light Co.	Robinson	■
26 - Duke Power Co.	McGuire	■■
27 - Duke Power Co.	Catawba	■■
28 - Duke Power Co.	Oconee	■■■
29 - South Carolina Electric & Gas	Summer	■
30 - Tennessee Valley Authority	Sequoyah	■■
31 - Tennessee Valley Authority	Watts Bar	□□
32 - Tennessee Valley Authority	Bellefonte	□□
33 - Tennessee Valley Authority	Browns Ferry	▲▲▲
34 - Southern Company Services	Vogtle	■■
35 - Southern Company Services	Hatch	▲▲
36 - Southern Company Services	Farley	■■
37 - Florida Power Corp.	Crystal River	■
38 - Florida Power & Light Co.	St. Lucie	■■
39 - Florida Power & Light Co.	Turkey Point	■■
40 - Gulf States Utilities Co.	River Bend	▲
41 - Entergy Operations	Waterford	■
42 - Entergy Operations	Grand Gulf	▲△
43 - Entergy Operations	Arkansas	■■
44 - Union Electric Co.	Callaway	■
45 - Illinois Power Co.	Clinton	▲
46 - Commonwealth Edison Co.	Quad Cities	▲▲
47 - Commonwealth Edison Co.	Byron	■■
48 - Commonwealth Edison Co.	La Salle	▲▲
49 - Commonwealth Edison Co.	Dresden	▲▲
50 - Commonwealth Edison Co.	Zion	■■
51 - Commonwealth Edison Co.	Braidwood	■■
52 - CAPCO[2]	Davis-Besse	■
53 - CAPCO[2]	Beaver Valley	■■
54 - CAPCO[2]	Perry	▲
55 - Detroit Edison Co.	Fermi	▲
56 - American Electric Power Co.	Cook	■■
57 - Consumers Power Co.	Palisades	■
58 - Consumers Power Co.	Big Rock Point	▲
59 - Wisconsin Public Service Corp.	Kewaunee	■
60 - Wisconsin Electric Power Co.	Point Beach	■■
61 - Northern States Power Co.	Monticello	▲
62 - Northern States Power Co.	Prairie Island	■■
63 - Iowa Electric Light & Power Co.	Arnold	▲
64 - Omaha Public Power District	Fort Calhoun	■
65 - Nebraska Public Power District	Cooper	▲
66 - Kansas Gas & Electric Co.	Wolf Creek	■
67 - Texas Utilities Electric Co.	Comanche Peak	□□
68 - Houston Lighting & Power Co.	South Texas	■■
69 - Arizona Public Service Co.	Palo Verde	■■■
70 - Southern California Edison Co.	San Onofre	■■■
71 - Pacific Gas & Electric Co.	Diablo Canyon	■■
72 - Portland General Electric Co.	Trojan	■
73 - WPPSS[3]	WNP 1 & 2	□▲
74 - WPPSS[3]	WNP 3	□

[1] Yankee Atomic Group consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

[2] CAPCO = Central Area Power Coordinating Group

[3] WPPSS = Washington Public Power Supply System

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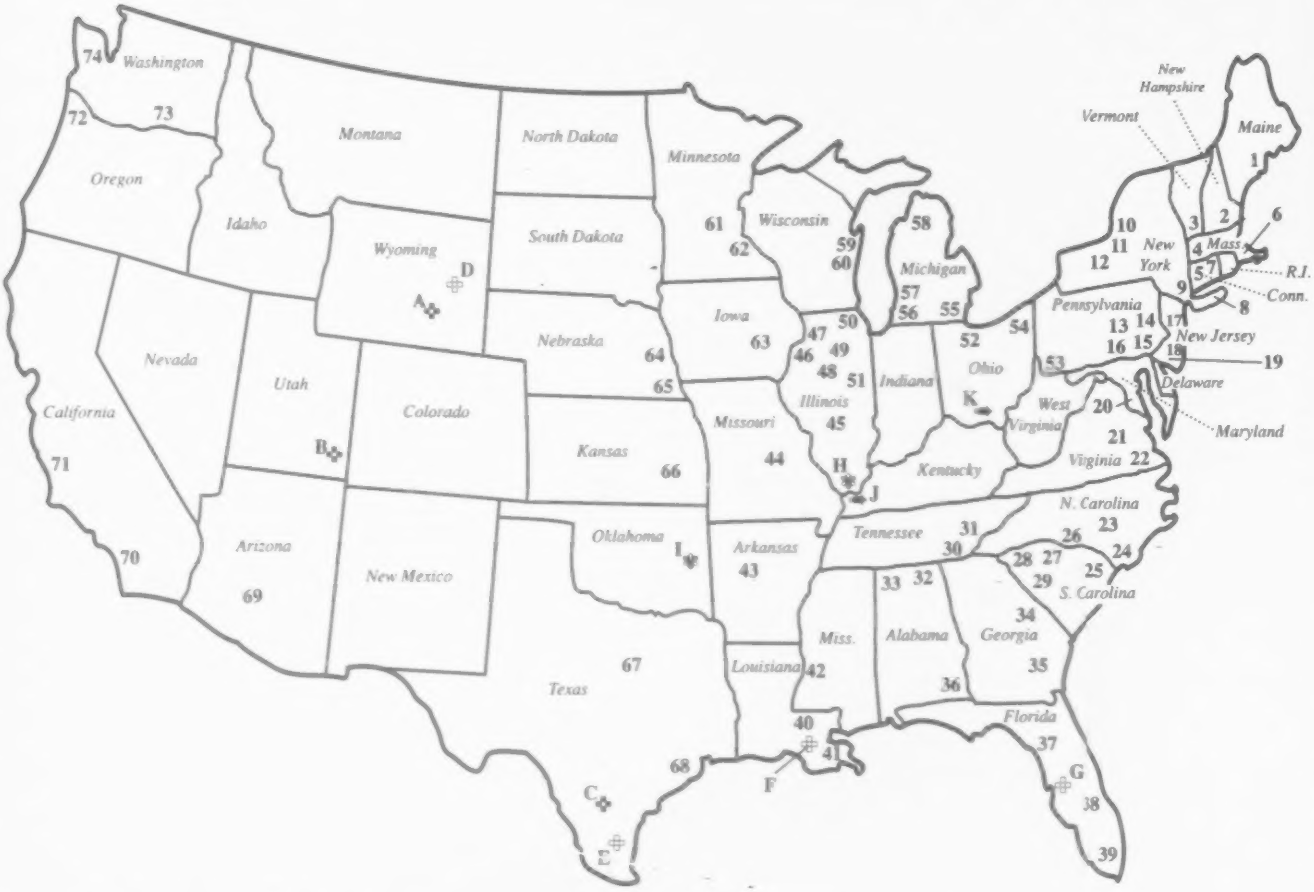
Figure 28
US LICENSED NUCLEAR POWER STATIONS AND FUEL CYCLE FACILITIES


Washington
74
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Oregon
Idaho
Montana
North Dakota
Minnesota
South Dakota
Wyoming
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Wisconsin
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59
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Michigan
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Maine
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Vermont
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Indiana
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West Virginia
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S. Carolina
Tennessee
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Arizona
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New Mexico
Oklahoma
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Arkansas
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33
32
Alabama
Georgia
34
35
Miss.
Louisiana
42
36
Texas
67
40
41
F
68
Florida
37
G
38
C
E
39

Key	Company	Location
A ✤	= Fathfinder Mines	Shirley Basin
B ✤	= Umetco/Energy Fuels	Blanding
C ✤	= Chevron Resources Co.	Panna Maria
D ⊕	= Power Resources	Highland
E ⊕	= Uranium Resources	Kingsville
F ⊕	= Freeport Uranium	Donaldsville & Uncle Sam
G ⊕	= IMC[1]	New Wales & Plant City
H ⬢	= Allied Chemical Corp.	Metropolis
I ⬢	= Sequoyah Fuels Corp.	Gore
J ➡	= Department of Energy	Paducah
K ➡	= Department of Energy	Portsmouth

FUEL CYCLE FACILITIES

[1] IMC = International Minerals and Chemical Corporation

Legend

Number or symbol indicates location

- ■ = PWR in commercial operation
- □ = PWR under construcion or planned
- ▲ = BWR in commercial operation
- △ = BWR under construction or planned
- ✤ = Uranium Production (conventional)
- ⊕ = Uranium Production (solution or by-product)
- ⬢ = Conversion Plant
- ➡ = Enrichment Plant

Electric's Limerick Unit 2 was connected to the grid in September and entered commercial service on January 8, 1990. The unit is a 1,055-MWe BWR, the last BWR likely to enter service in this century. The construction backlog includes only two other BWRs, Perry 2 and Grand Gulf 2, both of which have been indefinitely deferred (**Table 33**). The Limerick unit is notable in that construction was ordered suspended in 1982 by the Pennsylvania Public Utilities Commission (PUC) because of cost overruns and concerns about the utility's financial health. The utility resumed construction in 1986, completing the unit ahead of schedule and $382 million below the PUC's cost cap.

In other developments, the long-delayed Seabrook plant received a low-power license in May 1989. Lead owner Public Service Company of New Hampshire (PSNH) had declared bankruptcy due to the financial burden of Seabrook, and it appeared the unit might never operate. Highly organized and powerful opponents in New Hampshire and Massachusetts were primarily responsible for the delays, which stemmed from intervenors' refusal to cooperate in the emergency evacuation planning. With most of those problems resolved, however, the Nuclear Regulatory Commission monitored the low-power testing and issued a full-power license on March 1, 1990.

Table 33
INCOMPLETE US NUCLEAR POWER UNITS

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	Percent Complete[1]	COD[2]
Under Construction					
Comanche Peak 1	Texas Utilities Electric Co.	1,150	PWR	100	1990
Comanche Peak 2	Texas Utilities Electric Co.	1,150	PWR	86	1992
Watts Bar 1	Tennessee Valley Authority	1,177	PWR	100	1991
Total MWe		**3,477**			
Indefinitely Deferred					
Bellefonte 1	Tennesse Valley Authority	1,213	PWR	89	Indefinite
Bellefonte 2	Tennesse Valley Authority	1,213	PWR	58	Indefinite
Grand Gulf 2	Entergy Operations	1,250	BWR	33	Indefinite
Shoreham	Long Island Lighting Co.	809	BWR	100	Indefinite
Watts Bar 2	Tennessee Valley Authority	1,177	PWR	85	Indefinite
WNP 1	WPPSS[3]	1,250	PWR	65	Indefinite
WNP 3	WPPSS	1,240	PWR	75	Indefinite
Total MWe		**8,152**			

[1] Source: *Nuclear News*

[2] COD = Commercial Operation Date (expected)

[3] WPPSS = Washington Public Power Supply System

Independent of the operating schedule for Seabrook, Northeast Utilities held discussions with PSNH regarding the acquisition of PSNH for approximately $2.3 billion. A number of regulatory and legislative approvals will be necessary to complete the acquisition, including the transfer of the NRC license for Seabrook, but at the end of 1989 PSNH officials had endorsed the bid and were continuing to pursue commercial operation of the unit.

In Texas, Unit 1 of the two-unit Comanche Peak plant is nearing commercial operation after years of construction delays and intervention. In mid-1988, Texas Utilities Electric Company settled with a local intervenor group; among other things, the settlement allows a representative of the intervenor group to participate in the plant's operational review. Following licensing of Unit 1, Unit 2 is scheduled for operation in mid-1992.

The year was not without its setbacks, however. In a development that could set a precedent for other troubled plants, the voters of Sacramento, California approved a ballot initiative opposing further operation of the Rancho Seco nuclear plant by the Sacramento Municipal Utility District (SMUD). The plant had a history of poor performance (its 15-year average capacity factor was 38 percent), and SMUD was forced to raise rates 70 percent over the previous four years. After unsuccessful attempts to sell the unit, SMUD has begun evaluating ways to dispose of the plant's assets.

In another historic case, Long Island Lighting's (LILCO) Shoreham unit was sold to a New York state agency for the sum of $1, in exchange for substantial rate hikes for LILCO and the promise the State would shut down and pay for the plant's decommissioning. Built at a cost of $5.5 billion, the 800-MWe BWR had operated for a short time at 5% power and had received a full-power license. In July 1989, the utility began removing fuel rods from the reactor and has sold some of its fuel inventory assets. At present, the plant's future remains uncertain, as the Bush Administration has tried to prevent its decommissioning.

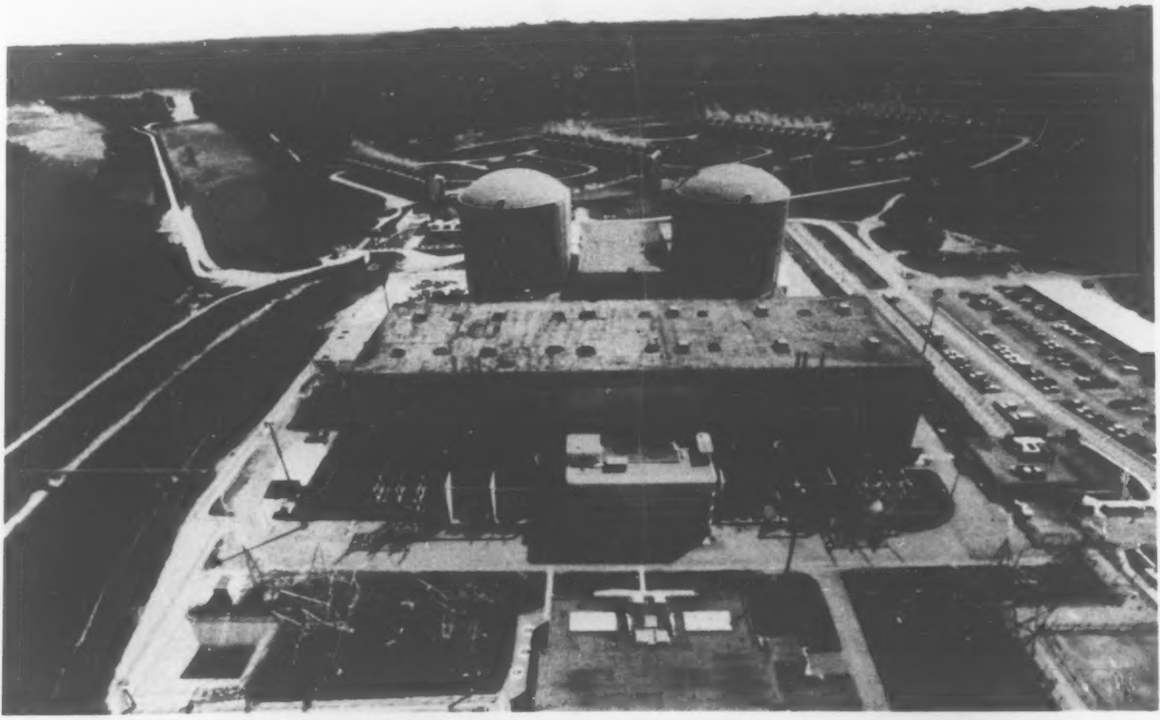

Figure 29. Northern States Power Company's Prairie Island 1 and 2 (500-MWe BWRs) located in Red Wing, Minnesota. *(Photo courtesy of Northern States Power Company)*

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Thus, a remote possibility still exists that the unit someday will operate. If it does not, it will be the only nuclear plant completed in the USA that was not permitted to operate. In the meantime, the metropolitan New York area is facing electricity shortages and is highly dependent on oil-burning generation facilities.

Public Service Company of Colorado's Fort St. Vrain unit, the nation's only commercial high-temperature gas-cooled reactor, had been plagued by maintenance problems and extended outages for much of its operating life. In early 1989, the unit's owners announced plans to operate the facility until mid-1990, and subsequently decommission the reactor. Instead, in August 1989, the utility announced that it would shut down the unit immediately due to the high cost of repairs. Finally, Commonwealth Edison officially cancelled its planned Carroll County plant, a two-unit station that had been classified as "on order" since 1978. With that cancellation, every nuclear plant ordered in the USA since 1974 now has been cancelled.

Uranium Contracting

During 1989, approximately 11 US utilities entered into long-term uranium supply agreements for almost 21 million pounds equivalent U_3O_8 with producers worldwide. Nearly 15 million pounds were in the form of concentrates. Most of the sellers were US, Canadian, or Australian producers, and the utilities overwhelmingly preferred market-related pricing terms. US producers sold approximately eight million pounds.

Political and Regulatory Developments

Many of the political uncertainties facing the industry for the past four years were resolved early in 1989. The Uranium Producers of America formally withdrew their long-running lawsuit against the Department of Energy in January 1989, when the plaintiff filed a Motion to Dismiss Without Prejudice in the Federal District Court. In actuality, the suit was negated upon implementation of the US-Canada Free Trade Agreement, which went into effect on January 1, 1989. The producers' lawsuit had been the driving factor behind a number of developments in the uranium and enrichment markets since 1985, including the contested issue of price premiums for US-origin uranium and the validity of DOE's Utility Services enrichment contract. Other efforts at protecting the US uranium production sector legislatively have arisen since, mostly due to the efforts of New Mexico Senator Pete V. Domenici.

The inauguration of President Bush in January and the appointment of Admiral James Watkins as Secretary of Energy gave the nuclear industry hope that with pro-nuclear leadership at the highest levels of government for the first time since the Department of Energy was created, government support of nuclear energy as a viable option in the US energy mix will be forthcoming. Shortly after taking office, Secretary Watkins announced plans to create a national energy strategy, thus giving the industry the opportunity to present the nuclear option for consideration.

Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) played a key role during 1989. In April, the NRC announced sweeping modifications of its licensing regulations for nuclear power plants. The revisions include early site approval, the approval of standardized reactor designs, and the issuance of a combined construction permit and operating license. By holding public hearings prior to starting construction, the NRC hopes to resolve uncertainties involving design, siting, safety, and operation, prior to the commitment of significant construction funds by the utility. The NRC argues that these changes could halve the current 12-year construction period for US nuclear plants. While these new regulations represent an important step forward in simplifying the complicated regulatory environment for nuclear plants, controversy is likely over the issues of standardized plant designs and the number of public hearings allowed prior to plant operation.

In other NRC developments, bills were submitted in the House and Senate to reorganize the NRC into an Executive Branch agency headed by a single administrator. The current commissioners are split on whether a change is necessary, and the House is not motivated to make any changes to the organization at present. In June, NRC Commissioner Kenneth Carr became Chairman, as Lando Zech's term expired. Finally, a spokesman in October said that the agency is working on the regulatory framework for license extension. The Atomic Energy Act (AEA) currently provides for 40-year licenses, and the agency is considering extension of the reactor operation period to 50-60 years.

Restructuring of DOE Enrichment Enterprise

In July, the Senate passed the Comprehensive Uranium Act of 1989, which, if enacted into law, would restructure DOE's uranium enrichment enterprise into a government corporation [United States Enrichment Corporation (USEC)] to allow it the flexibility to compete in the international enrichment market. The bill would repeal Section 161v of the Atomic Energy Act and require the corporation to set prices that recover over time the costs of R&D, depreciation of assets, $364 million in "unrecovered government investment," investment for new capacity or new technology development, and a reasonable profit. The USEC would have a single administrator, appointed by the President, and a five-member Advisory Board to review the policies and performance of the new company. The government corporation would be required to consider privatization within five years. Thus, it would be authorized to issue approximately $3 billion of stock and borrow up to $2.5 billion from the private sector. The USEC would have access to, but not ownership of, AVLIS R&D.

Initially, the corporation would be exempt from licensing the gaseous diffusion plants (GDPs), but the NRC would have to promulgate regulations within two years with the intent of licensing them. Still unresolved is whether the NRC is capable of licensing 30-year old GDPs, and whether sufficient documentation exists to certify the plants. A decontamination and decommissioning fund would be established, along with a cost-sharing requirement with the military for environmental cleanup at the current plant sites.

To assist the domestic uranium mining industry, the bill would authorize $300 million from the government for mill tailings clean-up. It would also establish a National Security Uranium Reserve of 50 million pounds for military and government research purposes. Senator Domenici amended the original bill to create a voluntary uranium overfeeding program, which would allow utilities to deliver excess uranium to the new corporation. To the extent that such material reduced the power costs of EUP production, the customer would be credited with the savings.

Although DOE supports the concept of restructuring the enrichment enterprise, the Administration has objected to several provisions of the bill. The Justice Department is concerned that the bill would authorize the President to appoint and remove the Administrator, and is unclear on whether Congress or the President has oversight responsibility for the USEC. These new issues, raised prior to the final Senate vote, will have to be addressed before the administration will fully support this bill.

Efforts to encourage the House of Representatives to act on the bill were not successful. The House Science, Space and Technology Committee held several hearings on the administration bill—the uranium enrichment reorganization act. Several other versions of enrichment restructuring were introduced but never seriously considered. Other House committees with jurisdiction over the bill—Energy and Commerce and Interior—remain unconvinced of the urgency of improving DOE's enrichment competitiveness. Industry efforts to gain a hearing for any bill stalled in the House over disputes about the unrecovered debt the new corporation owes the Treasury, the necessity of licensing the GDPs, ownership of, and the ability to invest in new enrichment technology, and whether assistance to the uranium mining industry is appropriate.

Louisiana Energy Services

A potential new enrichment supplier to the USA—Louisiana Energy Services (LES)—was announced in June. A joint venture of Duke Power, Graystone Corp. (a subsidiary of Northern States Power), Louisiana Power & Light, and Fluor Daniel, Inc., LES plans to utilize Urenco's centrifuge technology. The 1.5 million SWU-per-year plant will be located in Claibourne Parish, Louisiana. Although none of the joint venture partners have committed to purchasing enrichment from the plant, the partners have combined annual requirements of about one million SWU. The plant is projected to cost $750 million, and construction is scheduled to begin in 1992, assuming licensing and technology transfer issues are resolved.

Radionuclide Emissions Regulations

Operating under a court-ordered deadline, the EPA published a proposed rule in March, which appeared to severely limit the amount of, and increased the reporting requirements on, radionuclide emissions. Section 112 of the Clean Air Act authorizes the EPA to publish National Emission Standards for Hazardous Air pollutants. EPA's first attempt at issuing a rule had been challenged in court, and the EPA was forced to recommence a rulemaking. When the final rule was promulgated on December 15, the industry felt it had succeeded in mitigating some of the more stringent aspects of the proposed rule.

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Underground uranium miners were most adversely affected. The new standard reduces the allowable dose to the public from 25 mrem/year to 10 mrem/year Effective Dose Equivalent (EDE). With the stricter emission standards, the additional cost of monitoring and reporting, and record-low uranium prices, many of the remaining operating (underground) mines and associated mills are likely to shut down rather than meet the costs of compliance.

The rule also applies to tailing piles, both for operating facilities and for those on standby or shutdown. The EPA has attempted to reduce the cancer risk to no greater than one in 10,000 to the maximum exposed individual (who is assumed to be an individual standing at the site boundary 24 hours a day for 70 years).

For NRC licensees, the EPA suspended implementation of the rule for 60 days to review the impact of dual regulation (by the NRC and the EPA) on these facilities. This grace period allows all NRC licensees the opportunity to petition the EPA to reconsider various aspects of the new rule. Although it is not expected to significantly affect nuclear power plants, the rule requires additional monitoring and recordkeeping, and opens the door for states to enact and enforce even stricter standards. Congress may address this dual regulation problem when it considers changes in the Clean Air Act.

Department of Commerce Study

In December 1988, the Secretary of Energy asked the Commerce Department to investigate, under Section 232 of the Trade Expansion Act, whether the President should adjust imports of uranium to protect American national security. The study is required if consumption of non-US uranium in the USA exceeds 37.5 percent of total consumption for two consecutive years. According to an Energy Information Agency (EIA) finding, US utilities imported 44 percent of their uranium requirements in 1986 and 51 percent in 1987.

The Commerce Department issued its findings on October 23, reporting that, although uranium "plays a critical role in the national security and energy independence of the U.S.," it was not imported into the country in sufficient quantity to be a threat to the national security.

After the Commerce Department announced its findings, 23 Senators wrote President Bush, noting the further demise of the domestic uranium industry (with the shutdown of Homestake's and Chevron's mining and milling operations in New Mexico), and asking the administration to continue its effort to ensure the survival of a domestic uranium industry and commit to active support for uranium enrichment restructuring legislation.

DOE's High-Level Waste Program

DOE made little progress on a civilian high-level spent fuel repository during 1989. Embroiled in political controversy, the program is far behind the schedule established in the 1982 Nuclear Waste Policy Act (NWPA). Active participation by Congress will be necessary if the program is to advance beyond its current status. Numerous lawsuits have severely impeded site selection and characterization, and the State of Nevada has made the licensing and permitting process an obstacle.

Under the NWPA, DOE is scheduled to begin accepting utility spent fuel in 1998 and the repository was scheduled to open in 2003. The State of Nevada's vehement opposition to the Yucca Mountain, Nevada site recommended by Congress in a 1987 amendment to the NWPA created more roadblocks. The amendment allows for a state veto, but only after the site has been characterized and recommended. In September 1989, Nevada Governor Bob Miller exercised the veto, albeit prematurely, and now the state is refusing to cooperate with DOE in site characterization.

DOE is also facing a number of other problems in the waste program.

◆ Congress expressed its displeasure with DOE's management of the program with funding cuts for FY1990.

◆ TRW, an unsuccessful bidder for the $1 billion management contract for the repository, has brought suit in an attempt to prohibit DOE from awarding the contract to Bechtel. A US Claims Court has found in favor of TRW, prohibiting DOE from awarding the contract to any company other than TRW.

◆ Various environmental issues have emerged, particularly regarding endangered desert wildlife.

◆ The NRC staff has voiced technical concerns regarding DOE's site characterization plans.

In the midst of these problems, DOE came under fire from several Congress members in October 1989 for the lack of progress in its waste program. DOE responded that a full review of the program was underway, and followed with the announcement extending the deadline for the repository until 2010. In the meantime, US utilities

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continue to store spent fuel on site in ponds and, increasingly, in dry cask storage. Most have sufficient storage space to last through the 1990s. Nevertheless, the lack of a comprehensive waste program may be the most significant single problem affecting the US nuclear industry, and it appears to be a problem that will exist for the foreseeable future.

The Production Sector

Uranium production in the USA totalled 13.5 million pounds equivalent U_3O_8 in 1989, essentially the same as the 1988 production level of 13.3 million pounds. Of the 1989 output, conventional methods produced 7.5 million pounds, while by-product and solution mining accounted for 3.6 million and 2.4 million pounds, respectively (**Table 34**).

The most important factor affecting US uranium producers in 1989 was the continued decline of uranium spot prices, which made profitable operations almost impossible. Several mine closures and production facility sales occurred during the year.

◆ Uranium Resources, Inc. (URI) announced that Kingsville Dome would be shut down indefinitely because it was economically advantageous to purchase necessary concentrates on the spot market rather than to produce.

◆ Chevron Resources decided to shut down Mt. Taylor and will allow the mine to flood if an equity partner or buyer cannot be located.

◆ Homestake Mining halted production at its New Mexico mines and closed its Grants mill in response to the Mt. Taylor closure.

◆ Freeport Uranium Recovery Corporation (FURC) shut down the primary recovery circuit located at the Sunshine Bridge (Donaldsonville), Louisiana plant in response to depressed spot market prices.

These four shutdowns will account for an annual loss of production totalling more than 3.5 million pounds equivalent U_3O_8. Early in 1990, additional closures were announced: Malapai closed its solution mining operations at El Mesquite, Texas and Irigaray, Wyoming; and Umetco announced the suspension of its operations on the Colorado Plateau (**Table 35**).

These closures are significant, since they affect uranium production facilities which have production costs at or below $20/pound U_3O_8. High-cost operations are no longer the only facilities being closed. Most of those facilities (especially in the USA) have already been closed and, in some cases, dismantled. Now the nuclear industry is witnessing the shutdown of low-cost production sources. No longer is viability the goal, survival has become the overriding concern.

Table 34
US URANIUM PRODUCTION BY TYPE
(Million Pounds Equivalent U_3O_8)

	1982	1983	1984	1985	1986	1987	1988	1989
Conventional	20.6	14.8	9.5	5.4	8.7	7.8	7.0	7.5
By-Product	3.2	3.1	3.1	3.6	3.5	3.8	3.9	3.6
Solution Mining	3.0	2.8	2.1	2.1	1.5	0.9	2.4	2.4
Total	**26.8**	**20.7**	**14.7**	**11.1**	**13.7**	**12.5**	**13.3**	**13.5**

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Table 35
US URANIUM PRODUCTION FACILITIES

Production Center	Location	Principal Owner	Type	Annual Capacity (thousand pounds equivalent U_3O_8)
OPERATING[1]				
New Wales	Florida	IMC	By-product (P_2O_5)	1,200
Plant City	Florida	IMC	By-product (P_2O_5)	800
Uncle Sam	Louisiana	Freeport	By-product (P_2O_5)	750
Ambrosia Lake	New Mexico	Rio Algom	By-product (minewater)	200
Grants	New Mexico	Homestake	By-product (minewater)	200
Grants[2]	New Mexico	Homestake	Conventional	300
Mt. Taylor[2]	New Mexico	Chevron	Conventional	1,600
Panna Maria/Rhode Ranch	Texas	Chevron	Conventional	1,500
Shirley Basin	Wyoming	Pathfinder	Conventional	500
White Mesa	Arizona/Utah	Energy Fuels	Conventional	3,200+
White Mesa[2]	Colorado/Utah	Umetco	Conventional	500+
El Mesquite[2]	Texas	Malapai	Solution	300
Highland	Wyoming	Power Resources	Solution	1,000
Hobson[2]	Texas	Everest	Solution	150
Irigaray[2]	Wyoming	Malapai	Solution	500
Kingsville Dome[2]	Texas	URI	Solution	1,000
STANDBY[1]				
Bingham	Utah	Energy Fuels	By-product (Cu)	150
Calgary	Alberta, Canada	Earth Sciences	By-product (P_2O_5)	120
Donaldsonville	Louisiana	Freeport	By-product (P_2O_5)	400
West Cole	Texas	Total	Solution	200
Canon City	Colorado	Cotter	Conventional	500
Gas Hills	Wyoming	Pathfinder	Conventional	500
Ambrosia Lake	New Mexico	Rio Algom	Conventional	2,500
Sherwood	Washington	Western Nuclear	Conventional	1,000
Sweetwater	Wyoming	Minerals Exploration	Conventional	1,000

[1] Status as of 12-31-89
[2] Announced plans to put operation on standby in 1990

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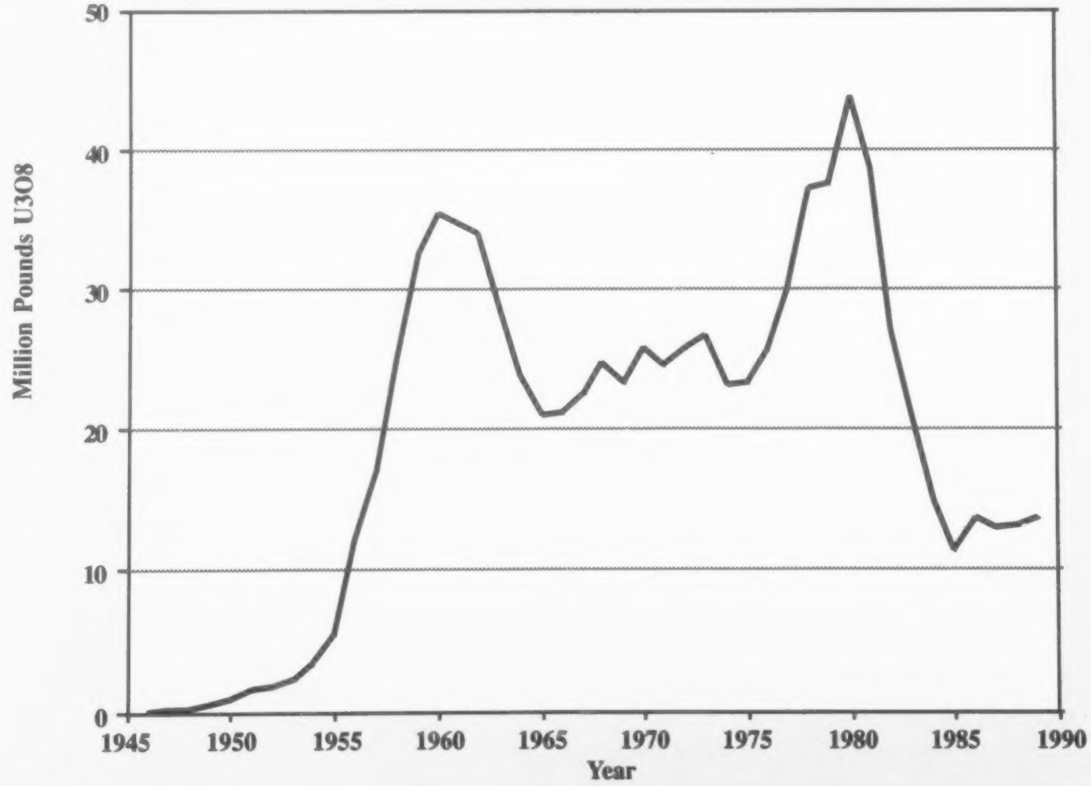
In September 1989, the US Department of Commerce found that uranium imports did not present a threat to national security. Nevertheless, production center closures have dominated the US industry since mid-year, and the Secretary of Energy found the industry to be "non-viable" for the fifth consecutive year (1984-1988).

Conventional Production

Uranium production from conventional sources increased to 7.5 million pounds equivalent U3O8, over 55 percent of total US uranium output in 1989. The Umetco/Energy Fuels White Mesa mill at Blanding, Utah was the most prolific US production center, with an output of 3.8 million pounds. The Umetco share amounted to 1.4 million pounds, up substantially from 1988, as a strong vanadium market provided the incentive for increased production of uranium/vanadium ores from mines on the Colorado Plateau.

Energy Fuels' share of 2.4 million pounds equivalent U3O8 was derived primarily from breccia-pipe ores of the Pigeon and Kanab North mines in northern Arizona. Development of these breccia pipes has been reduced in response to spot market prices, but production is continuing at modest levels. The Chevron/Total project at Rhode Ranch, Texas entered commercial operation in 1988 and has proven to be a cost-competitive production center, producing 1.25 million pounds in 1989. Other conventional producers included Chevron at Mt. Taylor, New Mexico (1.6 million pounds); Pathfinder at Shirley Basin, Wyoming (500 thousand pounds); and Homestake Mining at Grants, New Mexico (300 thousand pounds).

Figure 30
HISTORICAL US URANIUM PRODUCTION
1947-1989



Chevron announced in August that the Mt. Taylor mine would be closed and allowed to flood if a buyer or partner could not be found in the near term. The mine was placed on standby in January 1990 while the search for a buyer or partner continued. Homestake ceased conventional mining at its Section 23 mine concurrently with Chevron's announcement. The Homestake mill has been processing Mt. Taylor ore under a toll milling contract since late 1988, but was also placed on standby in January 1990.

In-Situ Leaching

In order to overcome low prices and aggressive foreign competition, a segment of the US uranium production industry over the years has chosen to pursue the commercialization of solution mining technology. Solution mining is playing an increasingly important role in the USA; during 1989, uranium produced from solution mining accounted for almost 18 percent of the US total.

In-situ leaching (ISL) production yielded 2.4 million pounds equivalent U_3O_8 in 1989, about the same as 1988. Uranium Resources, Inc.'s (URI) Kingsville Dome, Texas project produced over 700 thousand pounds, the same as Power Resources' Highland, Wyoming operation. URI announced in mid-1989 that, due to poor market conditions, production at Kingsville Dome would be cut back, ceasing in early 1990. Power Resources, a subsidiary of the UK's Central Electricity Generating Board (CEGB), purchased a 75-percent interest in the Highland project from Everest Exploration and its partners during 1989.

Malapai Resources produced a total of about 530 thousand pounds equivalent U_3O_8 from its Irigaray/Christensen, Wyoming and El Mesquite, Texas projects, but announced in January 1990 that both operations would close in February 1990 and were available for sale. Total Minerals produced 200 thousand pounds at West Cole, Texas, prior to being placed on standby in November, and Everest produced 150 thousand pounds at Hobson, Texas.

Despite these announcements, production costs for the more efficient solution mining projects are generally less than $15.00 per pound U_3O_8. Thus, based upon the current outlook for uranium market conditions, production facilities based upon in-situ leaching technology are likely to play an even greater role in the future.

By-Product Production

By-product recovery, another non-conventional uranium production technology, can also be commercially viable in a depressed market. Production levels had increased steadily until 1989, when by-product output fell slightly to approximately 3.6 million pounds equivalent U_3O_8.

By-product uranium recovery from phosphoric acid produced from Florida phosphate rock makes up most of US by-product operations. IMC Fertilizers' New Wales and Plant City facilities in Florida produced 1.3 and 0.8 million pounds equivalent U_3O_8, respectively. In Louisiana, Freeport Uranium Recovery Corp. (FURC) produced 700 thousand pounds at Uncle Sam, and over 300 thousand pounds at Donaldsonville. The Donaldsonville facility was placed on standby in late 1989.

Energy Fuels recovers uranium at Bingham, Utah as a by-product of copper operations. The recovery plant, which has an annual capacity of 150 thousand pounds equivalent U_3O_8, was placed on standby in March 1989. Homestake Mining and Rio Algom each produced about 200 thousand pounds from mine water at their New Mexico operations. ■

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